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E. H.

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---

* Rev. H. Moseley's 'Report on Greenwich Hospital Schools, 1845.

With the view of facilitating the introduction of physical geography as a subject of instruction into our elementary schools, the chapters are broken into short sections, or lessons, so that the work can be used as a Reading Book. No labour has been spared, either in the maps or the letter-press, in the effort to render the book at once interesting, instructive, and useful; and it is hoped that it will be found to deserve this character in schools generally, as well as by private pupils.

In the preparation of the work the author has consulted the writings of Humboldt, Ritter, Berghaus, Steffens, Sydow, Guyot, and Agassiz, as well as the various geographical works produced by our own writers.

E. H.

Royal Naval Schools,
Greenwich Hospital,
October 1849.

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# OUTLINES
# OF
# PHYSICAL GEOGRAPHY.

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## CHAPTER I.

DEFINITION. FIGURE AND DIMENSIONS OF THE EARTH. APPARENT MOTIONS OF THE HEAVENLY BODIES. DAY AND NIGHT. THE SEASONS.

PHYSICAL or Natural Geography comprises a knowledge of the figure and motions of the earth ; of the composition, structure, form, and distribution of the *solid* parts of its surface ; of the rivers and lakes that are spread over its land-masses ; of the extent, depth, tidal, and other movements of the ocean-waters which form its *liquid* covering ; of the properties and phenomena of the *aëriform* fluid termed the atmosphere, by which it is surrounded ; and, finally, of all animal and vegetable life.

As a department of human knowledge, it consists chiefly of leading facts of various branches of natural science, grouped with a special purpose. From a subject so broad and varied, at once embracing the earth, air, and ocean, with everything of vegetable and animal existence, we have selected, in the following pages, those portions which form the basis of all other geographical information, and which experience points out as adapted to the purposes of elementary education.

### FIGURE AND DIMENSIONS OF THE EARTH.

We shall now proceed to consider some of the facts, from which we conclude that the earth is a round or nearly spherical body.

A ship when sailing out to sea in any direction appears to persons on shore, to sink slowly below the surface of the water. As she recedes the hull gradually disappears, then the lower sails, and lastly the top sails, until the whole is lost to sight. Now, as the vessel increases her distance, she diminishes it is true in apparent size, but the distinctness with which the last portion of the sail is seen, satisfies us that the eye could follow her in her course, were it not for the intervening curved surface of the water which hides her from our view. Again, a person standing on the sea-shore, and watching with a telescope the approach of a ship far out at sea, would first get sight of the top sails, and it is not until she draws near land that the lower sails and hull come into view. A similar change is observed by persons on ship-board, as they approach or leave the land. The mountains and highlands appear to them to rise from the ocean, or sink into it; this appearance results from the convexity of the water between the eye and the object, and to enable them to look over this convexity, sailors go to the mast-head to look out for land. Two ships approaching each other under sail, in like manner, first become visible to each other from their respective mast-heads, the lower portions coming successively into sight.

When we ascend a high mountain, we obtain a more extensive view of the land, because, from our elevated position, we can look over more of the earth's curved surface, and in the same way, the higher aëronauts ascend, the greater is the portion of the earth that becomes visible to them.

If we sail out of sight of land, the surface of the sea, when viewed from the deck or mast-head of a ship, is not seen to lose itself in distance and mist, but to be terminated by a clear, sharp, well-defined line, called the *offing*, which runs all round us in a circle; in the centre of which we are stationed. Now, the same appearances are observed in every part of the earth's surface visited by man; therefore, the figure of a body which however seen always appears circular, can be no other than a sphere or globe.

The rotundity of the earth in the direction of east and west, is proved from the fact, that vessels having sailed continually on the same general course, return to the port from which they set out, that is, by sailing out from a certain port in an easterly direction, they have returned to it in a westerly direction, or vice versâ. Magellaen, Drake, and Anson, were among the first who circumnavigated the globe; but ships are now almost daily prosecuting such voyages. European ships sail to Australia, eastward round the Cape of Good Hope, and return by pursuing their course in an easterly direction through the Pacific, and round Cape Horn.

As we travel for any considerable distance from north to south, or from south to north, new stars gradually appear in the direction in which we are advancing, and disappear in that part of the heavens from which we are receding. Now this can only happen when the traveller is moving over a curved surface, in which case his *horizon* moves with him. Those who sail from northern latitudes to the Cape of Good Hope, or further south, observe as they voyage onward, that night after night they gradually lose sight of the northern stars, and other stars appear towards the south, and as they return homeward, the southern stars disappear and the northern stars come into view. Now this appearance leads us to the conclusion, that the surface of the earth is somewhat curved in the direction of north and south. If the earth were a cylinder with its axis in the direction of north and south, the north and south circumpolar stars would always appear above the horizon of the traveller or voyager, as he approached or receded from the equator.

When cutting for a canal we find that we must allow a dip of about eight inches in a mile in order to keep the water of a uniform depth throughout. If the earth were a plane, no allowance of this kind would be requisite; hence we know that the earth's surface is curved. Again, when we accurately measure a triangle of considerable area upon the earth's surface, we find that the sum of the three angles is greater than two right angles. Now this is always the case in all spherical triangles. This, then, is an additional proof of the earth's sphericity.

We might be led to conclude by analogy from the figure of the sun, moon, and planets, that the earth was of a similar shape; but this is placed beyond doubt by lunar eclipses, which occur in consequence of the moon, when at or near her nodes, entering the earth's shadow. The boundary of light and shade is always found to be circular, and since the earth is in various positions at the successive periods of eclipses, this uniformity of the shadow upon the face of the moon, proves that the earth which casts this shadow must be round in every direction, or of a globular form. Were the earth a disc, it would, when in certain positions relative to the sun and moon, project an oval shadow, or that of a right line, or some other figure different from that which it has always been found to assume. The curvature of the land differs but little from that of the ocean, as is evident from the courses of large rivers, which are navigable to a considerable extent. The mountains and highlands upon the earth's surface are therefore inconsiderable, when compared with the whole mass of the earth.

From what has been here stated, it follows that the surface of the earth is curved in every direction, and is, therefore, somewhat of a spherical form. But its true form and size have been determined by measurements taken upon different portions of its surface. Arcs of a meridian have been measured upon several parts of the earth, from the equator towards the poles, by distinguished astronomers of various nations. The result of these measurements shows that the earth's curvature is greater near the equator than towards the poles, or in other words, that the earth is flatter at the poles than at the equator: such a solid figure is called an oblate spheroid. It has also been shown that the polar diameter of the earth is about 26 miles shorter than the equatorial.

The figure of the earth has also been deduced from pendulum experiments. Were the earth a perfect sphere, its attraction on bodies at its surface would be every where the same, and the velocities imparted to a weight when allowed to fall freely from the same height at different places would be equal. Now the pendulum is in fact a falling body, and the greater the force of gravity, the greater the number of its oscillations in a given time. It has been found that a pendulum of a certain form and length, makes about 240 vibrations more in a day when near the pole than near the equator, hence, we conclude that the force of gravity is less at the equator than towards the poles. Numerous and careful experiments of this kind have been made in different latitudes, and their general results agree well with those derived from computation on the supposition that the earth is a spheroid.

The following are the measurements of the earth as determined by Laplace :—

| | English Miles. |
|---|---|
| Equatorial diameter | 7,924 |
| Polar diameter | 7,898 |
| Mean diameter | 7,916 |
| Mean circumference | 24,869 |
| Mean length of a degree | 69·08 |

Surface, 196 millions of square miles.
Solidity, 259 billions of cubic miles.

The polar diameter is, therefore, 26 miles shorter than the equatorial.

The density of the earth is about five times that of water.

Mass of earth is $\frac{1}{337086}$ of the mass of the sun.

Weight of a body at equator: ditto at poles : : 1 : 1·00569.

Length of seconds pendulum at equator = 39·027 in., ditto at poles = 39·197 in.

Centrifugal force at equator is about $\frac{1}{289}$ of gravity; and if the rotary motion of the earth were 17 times greater than it is, bodies at the equator would have no weight.

## Apparent Motion of the Heavenly Bodies. Rotation of the Earth about its Axis.

Let us for a moment consider the general phenomena of the motions of the heavenly bodies. In the morning the sun rises above the eastern horizon, ascends obliquely, and sets in the evening below the western horizon. The moon also, when visible, is seen to rise in the east, pursue a course similar to that of the sun, and to sink in the west.

If on a fine night we look out on the heavens, they will appear to undergo a continual change. If we watch the eastern horizon, through the whole extent from north to south, we shall see some stars rising; and if we watch the western horizon throughout the whole extent from north to south, we shall see other stars setting. We shall also observe that the stars do not rise perpendicularly, but slopingly; that they continue to rise till they reach a certain point towards the south intermediate between east and west, where they culminate, as it is called, and then they decline and set below the western horizon at points equidistant from the north as those in which they rose: similarly in the east a great number of stars will appear rising, reaching their greatest heights, and setting; but if we look to the north we shall see stars that never set, but move round a star that appears nearly stationary, called the polar star, and the stars describing circles round it are called circumpolar stars. Some stars appear just to touch the northern horizon, whilst others, situated at greater distances from the polar star, move round it in circles so large that their lower portions are lost below the horizon. These stars rise in the east, pass the south, set in the west, and disappear below the horizon till they rise again in the east.

To the inhabitants of the southern hemisphere, the heavens present an appearance the reverse of this. The stars near the south pole are seen to describe complete circles, whilst those more to the north are only seen in part of their course, and those near the north pole never rise above the horizon.

The stars, though of different magnitudes and different degrees of brightness, all appear at the same distance from us, and a further examination of the heavens will reveal to us the fact that the stars do not approach or recede from one another, but that they retain the same relative distance towards each other. Some stars, however, called planets, will be observed to change their places continually, whilst the sun and moon, the two celestial bodies of greatest interest to us, from day to day vary their places in the heavens.

From such appearances an observer would conclude that the concave surface, or the sphere of the heavens in which the stars appear to be fixed, turns about an axis, and that the direction of this axis is not far from the polar star. Now, if we select a star, and observe it by means of an equatorial instrument when the star is on the meridian, or culminating, and note the time that elapses until it comes on the meridian again, we shall find it to be exactly 23 hours 56 minutes, and in the same period of time all the stars appear to describe parallel circles round the axis of the heavens; hence we may say, that the sphere of the heavens performs one revolution in 23 hours 56 minutes, or a sidereal day.

Now it is evident that the same effect will be produced if the stars remain at rest, and the earth revolve uniformly round the same axis in the same time, but in the opposite direction. A spectator, not being aware of his own motion, would refer the whole change of relative position to the stars. For suppose he were travelling in a railway carriage, and that he were told that the train was at rest, and that the banks, fields, trees, villages, and towns were moving past him, he could not be brought to believe such an assertion, he would be convinced that the objects did not pass him, but that he was himself in motion in the opposite direction. The same argument holds good when applied to the heavens.

The mean distance of the moon from the earth has been calculated to be about 240,000 miles; now we know that the sun is more distant than the moon, because a solar eclipse is caused by the moon passing in front of the sun. The mean distance of the sun from the earth has been estimated at 95,000,000 of miles; and the nearest of the fixed stars (61 Cygni) is at a distance not less than 600,000 times that of the sun.

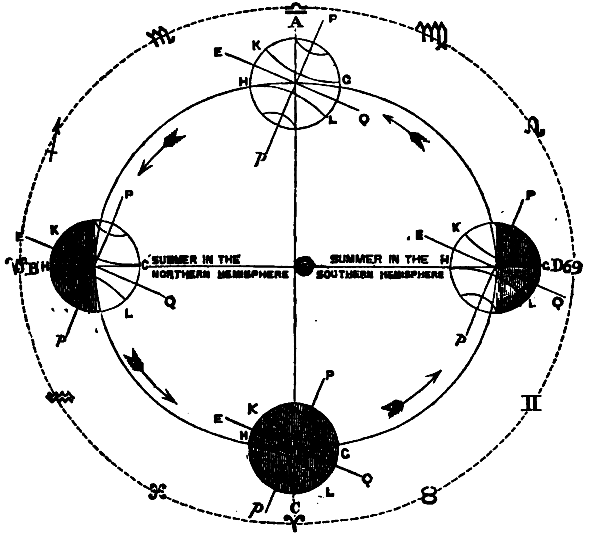
Let us suppose the moon, the sun, and the stars to revolve round the earth in about 24 hours, which they should do in order to produce the phenomena before described; in this case the moon would have to move at the rate of 60,000 miles per hour, the sun very much quicker, and the stars at a velocity of which we have no conception.

Sometimes spots upon the sun appear to travel its whole disc, from the eastern to the western limb, after some time, and emerge again on the eastern limb, a proof that he revolves about his axis; and observations further show that he makes a complete revolution in about 25½ of our days. The moon is found always to present the same face towards the earth, a fact that can be explained only on the supposition that she performs one revolution about her axis in a lunar month. Observations on the planets show that they revolve from west to east about their axes; and since this motion appears to be the law of the planetary system, we naturally conclude that the earth does not form an exception to the rule, but that she revolves about her axis from west to east. Now, since the sun, moon, and planets are known to revolve, the question we have to decide is this: whether is it more likely that this great framework of the heavens is turning one way, or that this small earth of ours is turning the other way? Reason tells us that we have only to look abroad upon the great works of nature to be convinced that God always employs the simplest means in accomplishing his ends. One revolution of the earth about its axis in about 24 hours would bring about the daily phenomena of the heavens, and this revolving motion we believe the Almighty has assigned to the earth, because it is in harmony with the simplicity, beauty, and economy of those portions of His works which are more evident to our senses, and is characteristic of the plans and operations of that Being who is "wonderful in counsel and excellent in working;" "who hath established the world by His wisdom, and stretched out the heaven by His understanding;" "who hangeth the earth upon nothing."

## DAY AND NIGHT. THE SEASONS.

Kepler, about three centuries ago, proved that not only the earth but all the planets describe elliptical orbits round the sun as a common centre, that body being in one of the foci of each of the ellipses. This law of the planetary motions is known by the name of *Kepler's first law.*

The orbit or path in which the earth revolves round the sun is of very small eccentricity, approaching almost to a circle. In consequence of the earth's motion, the sun seems in the course of a year to describe a circuit in the heavens called the ecliptic, and in the same direction as the earth actually describes it. The earth's axis is not perpendicular to the plane of the ecliptic, but is inclined to it at an angle of 66° 32′, and is carried forward in space preserving its parallelism in all positions, and pointing always to the same vanishing point in the sphere of the fixed stars. From these three facts, namely, the revolution of the earth about the sun, the parallelism of the earth's axis and the inclination of its axis to the plane of its orbit, the vicissitudes of the seasons may be explained.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A
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SUMMER IN THE NORTHERN HEMISPHERE
SUMMER IN THE SOUTHERN HEMISPHERE
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For this purpose let the above ellipse represent the earth's orbit, *i. e.* the path of the earth's progressive motion, near the centre of which the sun is represented by S. A, B, C, D, which are 90° apart, indicate four principal positions of the earth relatively to the sun. In each of these positions let P, *p* represent the axis of the earth, which is inclined to the plane of its orbit at an angle of 66° 32′

Now, since the earth is nearly a sphere, it is evident that only that half of it which is turned towards the sun can be enlightened at the same time. Therefore, in the different positions of the earth the bright or enlightened hemisphere is unshaded, and the dark hemisphere is represented by shaded lines to indicate the phenomena of day and night.

In the position A, the sun's rays fall perpendicular over the point of intersection of the equinoctial E Q and the ecliptic H G. In this case the circle of illumination passes through both poles, P, *p*, consequently it is day over half the northern and half the southern hemisphere at the same time; and as the earth turns on its axis, P, *p*, every part of its surface describes half its diurnal course in light and half in darkness, therefore, when the earth is in this position of her orbit, which is the case on the 21st of March, the duration of day and night is equal over the whole globe; hence this period of the year is termed the *vernal equinox*. The same phenomena occurs at the period of the year called the *autumnal equinox*, when the earth is at C on the 21st of September. This is represented in the diagram at C, where the unenlightened or night appearance of the earth is shown.

As the earth progresses in her orbit from the west through the south, and round to the east, she enters the summer solstice marked B on the 21st of June. Here we observe that the north pole P, and that part of the earth's surface 23½° from it towards B, lies within the enlightened half. The illuminated part is determined by a plane passing through the earth's centre, and perpendicular to a line joining the centres of the sun and earth: the intersection of this plane with the earth's surface is called the circle of light and darkness.

As the earth revolves about its axis, the whole of the region above 66½° north latitude, or 23½° from the pole, remains constantly enlightened; therefore, at this season of the year it is continual day within the arctic circle, or in the frigid zone, and as there will be a greater portion of the earth north of the equator in the enlightened than in the dark hemisphere, the days will be longer than the nights in northern latitudes. At the equator the days will be twelve hours long; but the nearer a point is to the north pole, the longer will it be in the bright and the shorter in the dark hemisphere, or, in other words, the longer will be the day and the shorter the night; on the contrary, the south pole P and the region lying within 23½° of it are immersed at this season in darkness or continual night.

When the earth, in her progress round the sun, has arrived at C, its axis still remaining parallel to its former position, the poles are in the boundary of light and darkness; therefore, as at A, the sun will be vertical to the equator, and all places on the earth's surface will have equal day and night: this will constitute the autumnal equinox. When the earth has arrived at D, its axis still continuing parallel to itself, the circle of light and darkness will first touch the arctic circle, and the phenomena which occurred at B will here be exactly inverted. The days and nights at the equator will be twelve hours long, but all places to the north of it will have short days and long nights, in proportion to their distance from the north pole; and this constitutes the winter solstice.

In consequence of the earth's annual motion, the sun appears to move through the ecliptic in the same direction in which the sun actually describes it; when the earth is at B the sun appears to be in the opposite point of the heavens, separated from the earth by 180° of longitude, and in the position which the earth will occupy after six months. For instance, the earth is at the beginning of the constellation Libra ♎, namely, on the 21st of March, the sun, S, as seen from the earth, appears at the beginning of Aries, in the opposite part of the heavens, and similarly of the other signs.

At the summer solstice, B, the circle, G K, which the sun then appears to describe in twenty-four hours, is called the tropic of Cancer 23° 28′ north of the equinoctial, and at the winter solstice, D, the circle, H L, which the sun appears to describe in twenty-four hours, is called the tropic of Capricorn 23° 28′ south of the equinoctial. These names are given to parallels equidistant from the earth's equator; the sun's rays, on the 21st of June, falling perpendicularly on the parallel 23° 28′ north of the equator, and on the 21st of December, on the parallel 23° 28′ south of the equator. Between these parallels, the inhabitants have the sun vertical, or in their zenith, on certain days in the year.

As the earth moves from A to B, the days gradually grow longer, and the nights shorter, in the northern hemisphere. As the earth passes from B to C, the length of the days gradually decreases, until the earth arrives at the position C, in the autumnal equinox; day and night are then equal. From this period the days are continually shortened, till, on the 21st of December, the earth has reached the winter solstice; we have at this season our shortest days and longest nights. From the winter solstice to the vernal equinox, the days constantly increase, and the nights decrease, until at the eastern point they are again equal.

Thus we see that the phenomena of day and night, and the changes of the seasons, may easily be explained, on the hypothesis that the earth turns upon its axis, that it revolves about the sun, and that its axis is inclined to the plane of its orbit. To these causes are due the change of the sun's declination, that is, they make the sun appear to describe a series of parallels to the equator, moving backwards and forwards between the tropics.

The mean distance of the earth from the sun = 93,321,724 English miles.

The time of sidereal revolution 365 d. 6 h. 9 m. 11·5 s.

The mean velocity of earth in its orbit 59′ 10·7″ each day.

The inclination of axis to ecliptic 23° 27′ 57″.

The belt of the earth's surface included between the tropic of Cancer and the tropic of Capricorn is called the torrid zone. The surface of this zone is estimated at 68½ millions of square miles. The inhabitants have the sun either perpendicular, or nearly so, during the whole year. Hence they receive a greater amount of heat, and experience less diversity of season, than the inhabitants of other portions of the globe.

The portions of the earth's surface situated between the tropic of Cancer and the arctic circle, and between the tropic of Capricorn and the antarctic circle, are called respectively the north and south temperate zones. The area of these zones is about 102 millions of square miles. The portion of the earth's surface between the arctic circle and the north pole is called the arctic, or *north frigid zone*, and that between the antarctic circle and the south pole is called the antarctic, or *south frigid zone*.

The earth is one of thirty-one (at present known) planets, which revolve about the sun in elliptical orbits. Those which move in orbits between the sun and the earth are called *inferior planets*, while those beyond the earth are called *superior planets*.

## KEPLER'S LAWS.

The laws of elliptic motion about the sun as a focus, and of the equable description of areas by lines joining the sun and planets, were originally established by Kepler, from a consideration of the observed motion of Mars; and were by him extended, analogically, to all the other planets. These laws are three:—

1. *That every planet moves so that the line drawn from it to the sun describes about the sun areas proportional to the times.*
2. *That the planets all move in elliptic orbits, of which the sun occupies one of the foci.*
3. *That the squares of the times of the revolutions of the planets are as the cubes of their mean distances from the sun.*

The announcement of these laws by Kepler led to a further inquiry into the causes which governed these movements. 1. From the first law, Newton concluded *that the force acting on the planets is directed towards the centre of the sun.* 2. From the second law, he determined *that the force acting on the planets is in the inverse ratio of the square of the distance of their centres from that of the sun.* 3. From the third law, he found *that the force is proportionate to the mass.*

## TABLE OF THE NAMES, CHARACTERS, AND APPROXIMATE MEAN DISTANCES OF THE PLANETS NOW KNOWN.

| *Name of Planet.* | *Character.* | *Mean Distance.* | *Discoverer.* | *Date of Discovery.* |
|---|---|---|---|---|
| MERCURY | ☿ | 36,890,000 | - - | Ancient. |
| VENUS | ♀ | 68,770,000 | - - | - - |
| EARTH | ♁ | 95,298,260 | - - | - - |
| MARS | ♂ | 145,205,000 | - - | - - |
| FLORA | ⚘ | 209,826,000 | Hind | 1847, Oct. 18. |
| MELPOMENE | - | 221,387,387 | Hind | 1852, June 24. |
| VICTORIA | ✵ | 222,373,000 | Hind | 1850, Sept. 13. |
| VESTA | ⚶ | 225,000,000 | Olbers | 1807, Mar. 29. |
| IRIS | ⊛ | 227,334,000 | Hind | 1847, Aug. 13. |
| METIS | ⊕ | 227,387,000 | Graham | 1848, Apr. 26. |
| HEBE | ⚱ | 231,089,000 | Hencke | 1847, July 1. |
| PARTHENOPE | ⚲ | 233,611,000 | De Gasparis | 1850, May 11. |
| THETIS | - | 232,222,799 | Luther | 1852, Apr. 17. |
| EGERIA | - | 244,940,000 | De Gasparis | 1850, Nov. 2. |
| ASTRÆA | ⚓ | 245,622,000 | Hencke | 1845, Dec. 8. |
| IRENE | - | 246,070,000 | Hind | 1851, May 19. |
| EUNOMIA | ♡ | 252,300,000 | De Gasparis | 1851. July 29. |
| JUNO | ⚵ | 254,312,000 | Harding | 1804, Sept. 1. |
| CERES | ⚳ | 263,713,000 | Piazzi | 1801, Jan. 1. |
| PALLAS | ⚴ | 264,256,000 | Olbers | 1802, Mar. 28. |
| HYGEIA | ⚕ | 300,322,000 | De Gasparis | 1849, Apr. 12. |
| PSYCHE | - | 309,261,913 | De Gasparis | 1852, Mar. 17. |
| JUPITER | ♃ | 495,817,000 | - - | Ancient. |
| SATURN | ♄ | 909,028,000 | - - | - - |
| URANUS | ♅ | 1,828,071,000 | Sir W. Herschel | 1780. |
| NEPTUNE | ♆ | 2,862,457,000 | { Adams and Le Verrier } | 1846, Sept. 23. |
| FORTUNA | - | - - | Hind | 1852, Aug. 22. |
| MASSILIA | - | - - | De Gasparis | 1852, Sept. 19. |
| LUTETIA | - | - - | Goldschmidt | 1852, Nov. 15. |
| CALLIOPE | - | - - | Hind | 1852, Nov. 16. |
| THALIA | - | - - | Hind | 1852, Dec. 15. |

We have now given the reader a sketch of the planetary condition of the earth, in order that some of the phenomena treated of in the following chapters may be more easily understood.

# CHAPTER II.

## STRUCTURE OF THE EARTH'S CRUST.

THE records of the Bible, together with human tradition, teach us that man and the animals associated with him were created by the word of God: "The Lord made heaven and earth, the sea, and all that in them is;" and this truth is confirmed by the revelations of science, which unequivocally indicate the direct interventions of creative power. But man and the animals which now surround him are not the only kinds which have had a being. The surface of our planet, anterior to their appearance, was not a desert. There are, scattered through the crust of the earth, numerous animal and vegetable remains, which show that the earth had been repeatedly supplied with, and long inhabited by, animals and plants altogether different from those now living. In general, their hard parts are the only relics of them which have been preserved, such as the skeleton and teeth of Vertebrates, the shells of the Mollusks and Radiata, the shields of the Crustaceans, and sometimes the wing cases of insects. Most frequently they have lost their original chemical composition and are changed into stone; and hence the name of *petrifactions* or *fossils*, under which latter term are comprehended all the organized bodies of former epochs obtained from the earth's crust.

To obtain an idea of the successive creations, and of the stupendous length of time they have required, it is necessary to sketch the principal outlines of Geology, than which no field of science presents more gratifying, astonishing, and (but for the evidence) incredible results. It teaches us that man has been but a few thousand years a tenant of this world; for nothing which we discover in the structure of the earth would lead us to infer that he existed at a period more remote than that assigned to him by the Scriptures. Had he been contemporary with the animals and plants of the early geological periods, we should have found his remains and his works entombed along with them.

This argument forcibly impressed the mind of Bishop Berkeley a century ago, and the following beautiful passage is cited from him by Sir Charles Lyell:—"To any one who considers that, on digging into the earth, such quantities of shells, and in some places bones and horns of animals, are found sound and entire, after having lain there, in all probability, some thousands of years, it would seem probable that gems, medals, and implements in metal or stone, might have lasted entire, buried under-ground forty or fifty thousand years, if the world had been so old. How comes it then to pass that no remains are found, no antiquities of those numerous ages preceding the Scripture accounts of time? that no fragments of buildings, no public monuments, no intaglios, cameos, statues, basso relievos, medals, inscriptions, utensils, or artificial works of any kind, are ever discovered, which may bear testimony to the existence of those mighty empires, those successions of monarchs, heroes, and demi-gods, for so many thousand years? Let us look forward for ten or twenty thousand years to come, during which time we will suppose that plagues, famine, wars, and *earthquakes*, shall have made great havoc in the world, is it not highly probable that, at the end of such a period, pillars, vases, and statues, now in being, of granite, or porphyry, or jasper (stones of such hardness, as we know them to have lasted two thousand years above-ground without any considerable alteration), would bear record of these and past ages? Or that some of our current coins might then be dug up, or old walls, and the foundations of buildings, show themselves, as well as the shells and stones of the *primeval world*, which are preserved down to our times?" This remarkable passage proves that the great man who penned it saw the geological argument in a true light, and felt its force to such a degree as to convince him of the great antiquity of the earth, which he justly viewed as in no way inconsistent with the comparatively recent origin of man, or with the historical account of both events contained in the Bible. It is easy to understand how such a mind would have been convinced, warmed, and excited even to enthusiasm, by the discoveries that have burst upon us during the last fifty years.

Hardly two centuries have passed since the astronomical doctrines of Galileo, Kepler, and Newton, were regarded as inconsistent with the Scriptures; but although the discrepancy of the literal meaning of the Bible with the real truths of astronomy is still as great as ever, no one any longer hesitates to regard astronomy as giving a just view of the stupendous mechanism of the universe; all agree in understanding the language of the Scriptures as being adapted to the *appearances* of the heavens, of which alone mankind in general can form any just conception, and with which alone the Scriptures are concerned. The Bible, being designed as a code of moral instruction, as a revelation of a future life, and of the sanctions that belong to that momentous subject, contains no systems of philosophy. Moral science, essentially contained in the Scriptures, is not, even there, presented in a regular form, as in human systems, but in modes more happily adapted to the actual condition and capabilities of mankind.

Instruction in the sciences was not the object of the Scriptures ; the physical creation was left by its divine author for the delightful exercise of our faculties, and to afford an inexhaustible source of mental and moral pleasure ; for application to use, to increase the power and the comforts of man, an equally unfailing fund of improvement, and for the additional illustration of the character of God.

By the " earth's crust" is meant that small portion of the exterior of our planet which is accessible to human observation, or on which we are enabled to reason by observations made at, or near the surface. The materials of this crust are not thrown together confusedly; but distinct mineral masses, called rocks, are found to occupy definite spaces, and to exhibit a certain order of arrangement.

The term *rock* is applied to all those substances which compose the earth's crust. The reader must bear in mind that in a geological sense, the term by no means implies a mineral mass in an indurated or stony condition, but substances whether they be soft or hard, as clay, sand, loose soil, and gravel, as well as the firm rock.

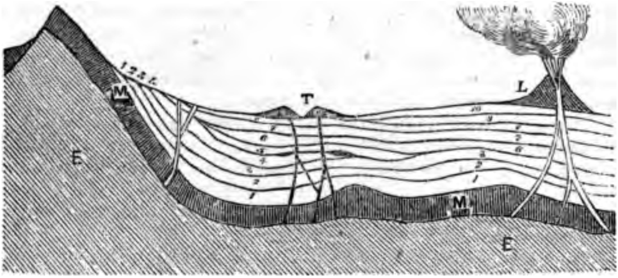
The rocks which compose the crust of our globe are of two kinds :—

1. The *Unstratified* or *Massive Rocks*, called also *Plutonic* or *Igneous Rocks*, which lie beneath all the others, or have sometimes been forced up through them, from beneath. They were once in a melted state, like the lava of the present epoch, and on cooling at the surface formed the original crust of the globe of granite, porphyry, basalt, &c.

2. The *Stratified* or *Sedimentary Rocks*, called also *Neptunian Rocks*, which have been deposited in water, in the same manner as modern seas and lakes deposit sand and mud on their shores, or at the bottom.

These sediments have been derived partly from the disintegration of the older rocks, and partly from the decay of plants and animals. The materials being disposed in layers or strata have become, as they hardened, limestones, slates, marls, or grits, according to their chemical and mechanical composition, and contain the remains of the animals and plants which were scattered through the waters.

We may here remark that underneath the deepest strata containing fossils, and between these and the Plutonic rocks, are generally found very extensive layers of slates without fossils (gneiss, mica-slate, talcose-slâte), though stratified, and known to the geologist under the name of *Metamorphic Rocks* (Fig. 1. M), being probably sedimentary rocks which have undergone considerable changes. The Plutonic rocks, as well as the metamorphic rocks, are not always confined to the lower levels, but they are often seen rising to considerable heights, and forming many of the loftiest peaks of the globe. The former also penetrate, in many cases, like veins, through the whole mass of the stratified and metamorphic layers, and expand at the surface; as is the case with the trap dykes, and as lava streams actually do now (Fig. 1. T, L).



The different strata, when undisturbed, are arranged one above the other in a horizontal manner, like the leaves of a book, the lowest being the oldest. In consequence of the commotions which the crust of the globe has undergone, many points of its surface have been elevated to great heights in the form of mountains; and hence it is that fossils are sometimes found at the summit of the highest mountains, though the rocks containing them were originally formed at the bottom of the sea. But even when folded, or partly broken, their relative age may still be determined by an examination of the ends of the upturned strata, where they appear or crop out in succession, at the surface or on the slopes of mountains, as seen in the diagram (fig. 1).

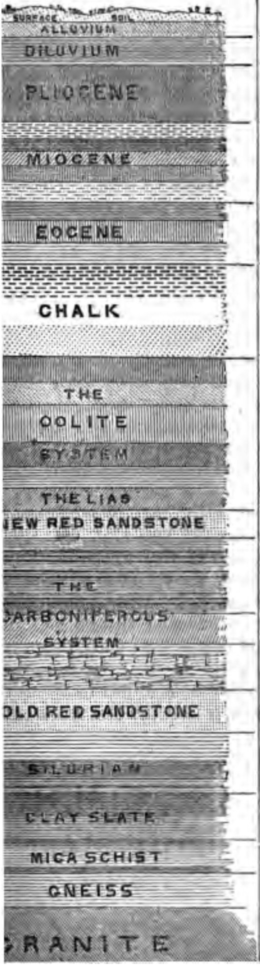
The sedimentary rocks are the only ones which have been found to contain animal and vegetable remains. They are found imbedded in the sediment, just as we should find them in the mud now deposited at the bottom of the sea, if laid dry. The strata containing fossils are numerous. The comparison and detailed study of them belong to geology, of which they form an essential part. A group of strata extending over a certain geographical extent, all of which contain some fossils in common, no matter what may be the chemical character of the rock, whether it be limestone, sand, or clay, is termed a geological *formation*. Thus, the coal beds, with the intervening slates and grits, and the masses of limestone in which they are often imbedded, constitute but one formation, the carboniferous formation.

Among the stratified rocks we distinguish ten principal formations, each of which indicates an entirely new era in the earth's history; while each of the layers which compose a formation indicates but some partial revolution. Proceeding from below upwards they are as shown in the cut on the opposite page, and also in the diagram on next page; which latter indicates the localities in which each formation is found in the British islands, the organic remains and character of each, and the use of each in the arts and manufactures.

These different formations comprise more than forty distinct layers, each of which marks a distinct epoch in the earth's history, indicating a more or less extensive and important change in the condition of its surface.

All the formations are not always found, or are not developed to the same extent, in all places. It is the same with the several strata of which they are composed. In other words, the layers of the earth's crust are not continuous throughout like the coats of an onion. There is no place on the globe where, if it were possible to bore down to its centre, all the strata would be found. It is easy to understand how this must be so. Since irregularities in the distribution of water upon the hard crust have, necessarily, always existed to a certain extent, portions of the earth's surface must have been left dry at every epoch of its history, gradually forming large continents and islands, as the changes were multiplied. And since the rocks were formed by the subsidence of sediment in water, no rocks would be formed except in regions then covered by water; they would be thickest at the parts where most sediment was deposited, and gradually thin out towards their circumference. We may therefore infer, that *all those portions of the earth's surface which are destitute of a certain formation were dry land during that epoch of the earth's history to which such formation relates*, excepting

| | *Localities.* | *Organic Remains.* | *Character.* |
|---|---|---|---|
| 4. Modern Age. | Estuaries, &c. | Man | Sand, Gravel, Clay |
| | Many parts of England | Colossal Animals | Drift, Erratic Blocks |
| 3. Tertiary Age. | Norfolk, Suffolk, Hampstead Heath, &c. | Proportion of existing species 49 per cent. The Mastodon. | Crag, Marine Conglomerates, &c. |
| | Isle of Wight and South-west of France, near Paris. | Proportion of existing species 18 per cent. Fresh-water Shells, Marine Mammalia. | Limestones, Clay, Marine Marls, Crag Sandstone. |
| | Middlesex, Essex, Surrey, Kent, Sussex, and Hampshire. | Proportion of existing species 3 per cent. The Palæothorium. | Clay, Gypsum, Sandstone. |
| 2. Secondary Age. | Cliffs at Dover and Brighton, Flamborough Head, Kent, &c., Isle of Wight. | Remains almost entirely Marine, Sponges, Corals, Mollusca, Crustacea, Reptiles. | Chalk with Flints, Chalk without Flints, Chalk Marl, Green Limestone. |
| | Weald of Kent, Surrey, Sussex, and Hampshire, Isle of Purbeck, Lynn to Portland, Oxfordshire and Lincolnshire, Tees mouth to Dorset. | First Mammalia, Tortoises, Ammonites, Crustacea, Insects, Flying Lizards, the Iguanodon, immense Saurians. "The Age of Reptiles." | Clay, Sand with Iron Ore, Argillaceous Sandstone, Portland Stone, Kimmeridge Clay, Limestone, Limestone with Shales, &c. |
| | Cheshire, &c., Yorkshire, &c. | Saurians, the Chiotherium | Fine Sandstone, Magnesian Limestone. |
| | Northern Counties, Somersetshire, South Wales, and South Scotland. | Luxuriant Vegetation, Ferns, Palms, and other gigantic Plants. | Coal-beds and Sandstone, with Ironstone, Clay, and impure Limestone. |
| | Northern Counties | Marine Shells and Plants | Millstone Grit, Sandstone |
| | Northern Counties, South Wales, &c. | Lily Encrinite, immense Shell-Fish, Zoophytes. | Mountain Limestone. |
| 1. Palæozoic Age. | North Scotland, Herefordshire, Devonshire. | Vertebrated Fish, Marine Plants, and Shells. | Sandstone, Conglomerates, Limestone. |
| | Border Counties of England and Wales and South Wales. | Corals, Shell-Fish, Trilobites, Sea-Weeds. | Sandstone and Slaty Limestone. |
| | North Wales, Cumberland, Westmoreland. | Polypi, Worms, and species of Mollusca. | Vast Slate Rocks and Dark Limestone. |
| Metamorphic Rocks. | Perthshire, Argyllshire | NO ORGANIC REMAINS. | Mica Slate & Quartz Rocks |
| | Ben Lomond | | Gneiss and Quartz Rocks |
| | Dartmoor Forest, North Wales, Cumberland, Highlands of Scotland, &c. | | Granite, Porphyry, Serpentine, Basalt, &c. |



| *Systems.* | *Uses in the Arts.* | *Mean Thickness in feet.* |
|---|---|---|
| SURFACE SOIL<br>ALLUVIUM | Glass Manufacture. | |
| DILUVIUM | Various. | |
| PLIOCENE | Building, Paving, &c. | 1350 |
| MIOCENE | Architecture, Potteries, Agriculture, Building. | |
| EOCENE | Potteries, Models, Architecture. | |
| CHALK | Building and Road-making, Agriculture, Manufactures. | 600 |
| THE OOLITE SYSTEM<br>THE LIAS | Potteries, Iron Manufacture, Paving, &c., Building, Potteries, Architecture, Building. | 2300 |
| EW RED SANDSTONE | Architecture. | 1200 |
| THE ARBONIFEROUS SYSTEM | Fuel, Gas, Building, Iron Manufacture, Potteries, various. | 3000 |
| | Millstones, Paving, &c. | 900 |
| | Building, and various. | 1800 |
| LD RED SANDSTONE | Building, Paving, Architecture. | 9900 |
| SILURIAN | Building, and various. | 7400 |
| CLAY SLATE | Roofing, Paving, Statuary, &c. | 9000 |
| MICA SCHIST | Building, Ornaments. | |
| GNEISS | Various. | |
| RANITE | Building, Road-making, &c. | |

indeed, where the rocks have been subsequently removed by the denuding action of water or other causes.

Each formation represents an immense period of time, during which the earth was inhabited by successive races of animals and plants, whose remains are often found, in their natural position, in the places where they lived and died, not scattered at random, though sometimes mixed together by currents of water, or other influences, subsequent to the time of their interment. From the manner in which the remains of various species are found associated in the rock, it is easy to determine whether the animals to which these remains belonged lived in the water or on land, on the beach or in the depths of the ocean, in a warm or in a cold climate. They will be found associated in just the same way as animals that live under similar influences at the present day.

In most geological formations, the number of species of animals and plants found in any locality of given extent is not below that of the species now living in an area of equal extent; for though, in some deposits, the variety of the animals contained may be less, in others it is greater than that on the present surface. Thus, the coarse limestone in the neighbourhood of Paris, which is only one stage of the lower tertiary, contains not less than 1,200 species of shells.

Nor was the number of individuals less than at present. Whole rocks are entirely formed of animal remains, particularly by corals and shells; so, also, coal is composed of the remains of plants. If we consider the slowness with which corals and shells are formed, it will give us some faint notion of the vast series of ages that must have elapsed in order to allow the formation of those rocks, and their regular deposition under the water, to so great a thickness. If, as all things combine to prove, this deposition took place in a slow and gradual manner in each formation, we must conclude that the successive species of animals found in them followed each other at long intervals, and are not the work of a single epoch.

## AGES OF NATURE.

Each formation contains remains peculiar to itself, which do not extend into the neighbouring deposits above or below it. Still there is a connéxion between the different formations, more strong in proportion to their proximity to each other. Thus, the animal remains of the chalk, while they differ from those of all other formations, are nevertheless much more nearly related to those of the oolitic formation, which immediately precedes, than to those of the carboniferous formation, which is much more ancient; and in the same manner the fossils of the carboniferous group approach more nearly to those of the Silurian formation than to those of the tertiary.

These relations could not escape the observation of naturalists; and, indeed, they are of great importance for the true understanding of the development of life at the surface of our earth. And as, in the history of man, several grand periods have been established, under the name of *Ages*, marked by peculiarities in his social and intellectual condition, and illustrated by contemporaneous monuments, so in the history of the earth also are distinguished several great periods, which may be designated as the various *Ages of Nature*, illustrated in like manner by their monuments, the fossil remains, which, by certain general traits stamped upon them, clearly indicate the eras to which they belong.

We distinguish four Ages of Nature, corresponding to the great geological divisions, namely :—

1st. *The Primary* or *Palæozoic Age*, comprising the lower Silurian, the upper Silurian, and the Devonian. During this age there were no air-breathing animals. The fishes were the masters of creation. We may therefore call it the *Reign of Fishes.*

2nd. *The Secondary Age*, comprising the carboniferous formation, the trias, the oolitic, and the cretaceous formations. This is the epoch in which air-breathing animals first appear. The reptiles predominate over the other classes, and we may therefore call it the *Reign of Reptiles.*

3rd. *The Tertiary Age*, comprising the tertiary formations. During this age, terrestrial mammals, of great size, abound. This is the *Reign of Mammals.*

4th. *The Modern Age*, characterized by the appearance of the most perfect of all created beings. This is the *Reign of Man.*

## CONCLUSIONS.

From the above sketch it is evident that there is a manifest progress in the succession of beings on the surface of the earth. This progress consists in an increasing similarity to the living fauna, and among the vertebrates, especially, in their increasing resemblance to man.

But this connexion is not the consequence of a direct lineage between the faunas of different ages. There is nothing like parental descent connecting them. The fishes of the Palæozoic age are in no respect the ancestors of the reptiles of the Secondary age; nor does man descend from the mammals which preceded him in the Tertiary age. The link by which they are connected is of a higher and immaterial nature; and their connexion is to be sought in the view of the Creator himself, whose aim, in forming the earth, in allowing it to undergo the successive changes which geology has pointed out, and in creating successively all the different types of animals which have passed away, was to introduce man upon the surface of our globe. Man is the end towards which all the animal creation has tended, from the first appearance of the first Palæozoic fishes.

In the beginning His plan was formed, and from it He has never swerved in any particular. The same Being who, in view of man's moral wants, provided and declared, thousands of years in advance, that "the seed of the woman shall bruise the serpent's head," laid up also for him in the bowels of the earth those vast stores of granite, marble, coal, salt, and the various metals, the products of its several revolutions; and thus was an inexhaustible provision made for his necessities, and for the development of his genius, ages in anticipation of his appearance.

To study, in this view, the succession of animals in time, and their distribution in space, is, therefore, to become acquainted with the progressive plan of the Great Creator. Now, if the succession of created beings on the surface of the globe is the realization of an infinitely wise plan, it follows that there must be a necessary relation between the races of animals and the epochs at which they appear. It is necessary, therefore, in order to comprehend creation, that we combine the study of extinct species with that of those now living, since one is the natural complement of the other.

## UTILITY OF GEOLOGY.

Geology, in addition to its inherent dignity, puts forth strong claims to regard on the ground of positive utility. From its application to the useful purposes of life, as in agriculture, building, the formation of roads and canals, and the sinking of wells and mines, it is highly interesting. Everything reposes upon the mineral kingdom; it affords to man, directly or indirectly, all the materials of his physical comfort, all those of national wealth, and all the means of civilization. The most important of physical instruments are derived, immediately or remotely, from it; for the vegetable world, equally with the animal, rests upon this basis: whether we speak of the cedar, the oak, the lichens, or the grasses, all equally derive their support from the elements afforded by the mineral kingdom; which, in its widest sense, includes not only the solid earth, but its waters, and all its fluids—its atmosphere, and all its gases. The vegetable kingdom borrows not a few elements from the mineral world; oxygen, carbon, hydrogen, and even nitrogen, and all that are indispensable to vegetable life, are found in the waters or in the atmosphere; while other elements or compounds, adapted to particular purposes, are derived from various mineral sources: the soil, for example, affords silica, which enters into the composition of the epidermis of grasses, bamboos, &c.; and potass and soda, derived from decomposed felspar and other minerals, pass by absorption into the juices of plants. Even animal and vegetable manures form no exception, for their elements have a similar origin, and consist almost entirely of the substances indispensable to vegetable growth.

Thus, while we explore this orb of gases, fluids, and solid rocks, we shall gain the most interesting knowledge and much positive advantage. Our beautiful planet is indeed worthy of our study; it was once our cradle—it will soon be our grave: between the dawn and the night of life it is the scene of our busy action, and from it we shall arise to another state of being.

# CHAPTER III.

## MAP I.

### DISTRIBUTION OF LAND AND WATER.

### I. *The Great Continents.*

LAND and water constitute the two great natural divisions of the earth's surface.

Upon referring to the Map, we observe that the land is arranged in the form of very large compact masses, denominated *continents*, or in small isolated portions, termed *islands*, the whole occupying about one-fourth part (or, more accurately, about three-tenth parts) of the surface of the globe. The larger masses of land are situated in the Eastern Hemisphere, or the hemisphere which is projected upon the plane of a meridian 20° to the west of Greenwich.

Europe and Asia, correctly speaking, form one continent lying wholly to the north of the equator, and having its greatest length, or *axis*, in a direction parallel to it. The greatest length of Africa is from north to south, about two-thirds of it lying to the north of the equator. From the south-eastern extremity of Asia there extends a wide archipelago, of which the vast isolated continent of Australia forms the nucleus of an island-world, spreading out into both hemispheres.

In the Western Hemisphere the great mass of land forming the American continent is more equally distributed on each side of the equator, and stretches in a meridional direction almost from pole to pole.

The consequence of this arrangement is, that the Asia-Europe continent extends through similar climatic zones, while America traverses nearly all the climatic zones of the earth, and presents in this relation a much greater variety of phenomena.

The entire superficies of the globe we have estimated at about 196½ millions of English square miles, of which the land occupies about 51 millions, and the ocean-waters about 145½ millions of square miles. In the Eastern Hemisphere there are about 37 millions of square miles of land, and in the Western Hemisphere about 14½ millions. The Eastern

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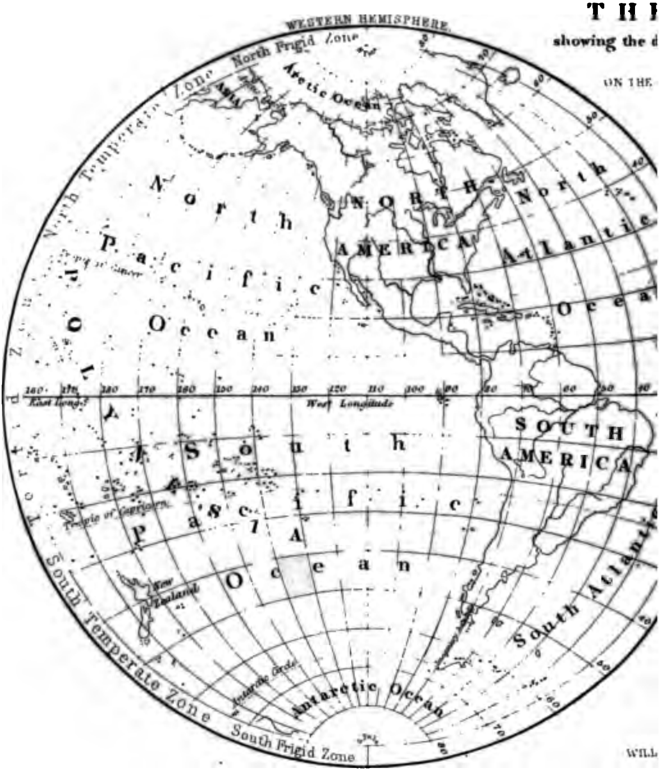

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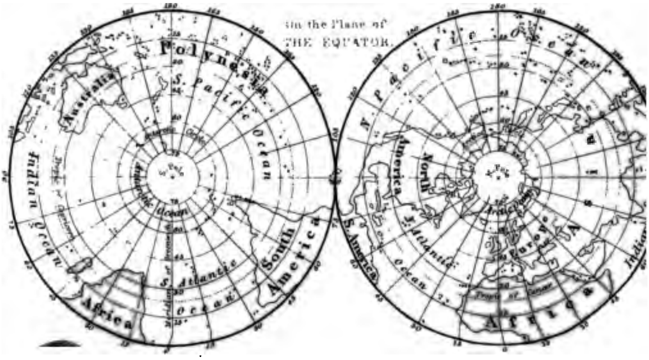

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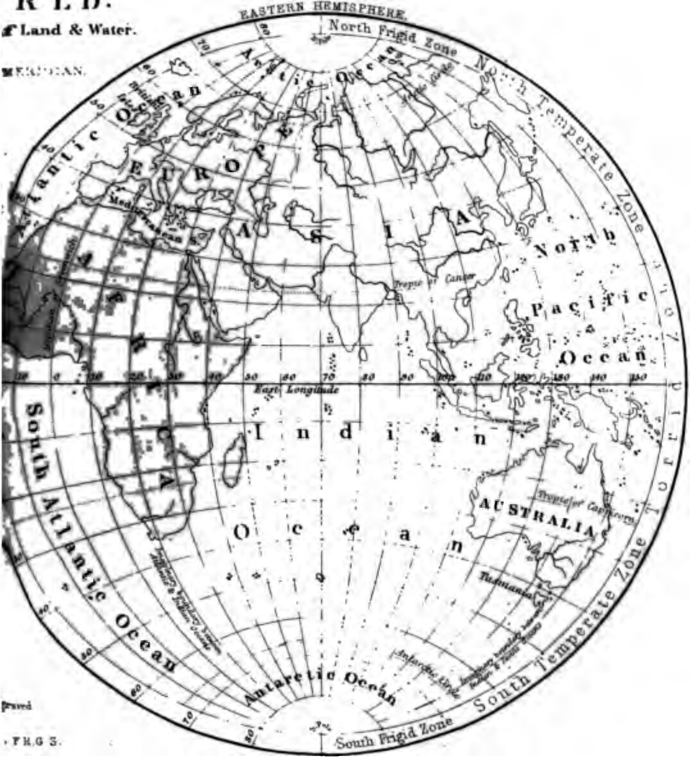
MERIDIAN.



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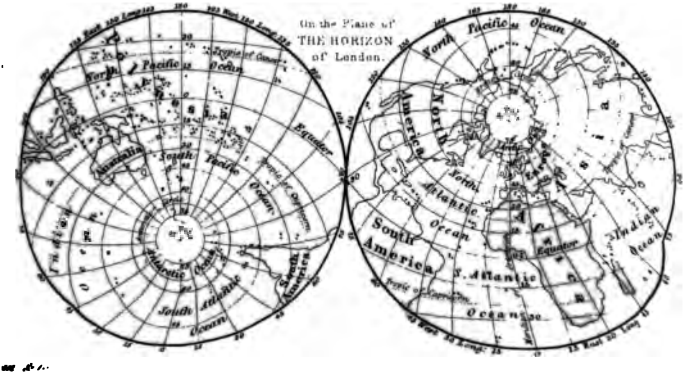

On the Plane of
THE HORIZON
of London.

Hemisphere, therefore, contains about 2½ times as much land as the Western. From a projection of the globe on the plane of the equator we have calculated that there are about 38 millions of square miles lying in the Northern Hemisphere, and 13¼ millions in the Southern; or that there is about three times as much land to the north of the equator as to the south of it.

The subjoined table exhibits the extent of the land-masses of the globe in English square miles:—

| | | |
|---|---|---|
| Europe, with its isles | | 3,432,000 |
| Africa, with Madagascar | | 11,420,000 |
| Continental Asia | 16,830,000 | 21,090,000 |
| Isles, including Australia, New Zealand, with the other islands of Polynesia | 4,200,000 | |
| North America | 8,100,000 | 15,300,000 |
| South America | 6,420,000 | |
| Islands | 160,000 | |
| Greenland (supposed) | 620,000 | |
| Total | | 51,242,000 |

The Ocean, with all its bays and seas, covers an area of 145,600,000 square miles, or nearly ¾ of the surface of the globe. About $\frac{7}{12}$ of the great body of waters lie in the Southern Hemisphere, and $\frac{5}{12}$ in the Northern.

The following is the comparative superficial extent of the Frigid, Temperate, and Torrid Zones, taking the whole area of the globe as unity (*Lacroix*):—

| | |
|---|---|
| The Frigid Zones occupy | ·083 |
| The Temperate Zones | ·519 |
| The Torrid Zone | ·398 |

The distribution of land is a subject exceedingly wide in its range, and of great importance, since it exercises the greatest influence upon temperature, the pressure of the atmosphere, the direction of winds, and the quantity of moisture contained in the air. These elements affect primarily the development of vegetation, and ultimately influence the civilization and social condition of man. "Give me," says M. Cousin, "the map of a country, its configuration, its climate, its waters, its winds, and all its physical geography—give me its natural productions, its *flora*, its *fauna*, and I pledge myself to tell you, *à priori*, what the inhabitants of that country will be, and what place that country will take in history, not *accidentally, but necessarily*; not at a particular epoch, but at all periods of time; in a word, the thought which that country is formed to represent."*

*Europe* has a political boundary on the east, formed by the Ural Mountains, the River Ural, and part of the north and west shores of the Caspian Sea; the line is thence continued along the range of Mount Caucasus and the northern shores of the Black Sea. Its extreme length from E. N. E. to W. S. W. (from the Ural Mountains near Orsk in Russia to Cape St. Vincent in Portugal) is 3,400 miles, and its greatest breadth, from North Cape in Lapland to Cape Matapan in Greece, is 2,450 miles. Its area, including the islands, amounts to about 3¼ millions of square miles.

*Asia.*—The greatest length of the mainland from north to south nearly coincides with the direction of the meridian of 105° east, that is, from Cape Taimura in Siberia to Cape Romania in Malaya, and is a little more than 5,300 miles. Its greatest breadth from west to east, along the parallel of 40° north latitude, or from Cape Baba in Asia Minor to the east coast of the Corea, is 5,600 miles. Its superficial area, including the islands of the Indian archipelago, is about 21 millions of square miles.

*Africa.*—The greatest length of this continent, from Cape Bon on the north (opposite Sicily) to Cape Das Agulhas on the south, is about 4,988 miles; and the greatest breadth from Cape Verde on the west to Cape Gardafui on the east is about 4,618 miles; its superficial area, with that of Madagascar, is a little short of 11¼ millions of square miles.

*America.*—The greatest length from Point Beachy on the Arctic Ocean to Cape Horn on the south is about 10,875 miles; the greatest breadth of North America, along the parallel of 51° north latitude, is about 3,250 miles; and of South America, from Cape San Roque in Brazil to Cape Blanco in Peru, 3,200 miles. North America contains an area of about 8,000,000 square miles, South America about 6,500,000, and the West India Islands, with other islands along the coast, about 160,000; or altogether the continent with the islands include an area of about 15,300,000 square miles. In this estimate Greenland and the Arctic Islands are included.

*Australia*, from its vast extent, is frequently considered as a continent. Its greatest length from east to west is 2,400 miles, and greatest breadth from north to south 1,970 miles. The superficial area is 3 million square miles.

If we compare the relative magnitudes of the great continents, and assume the area of Australia as the unit of measurement, we obtain the following :—

---

* Histoire de la Philosophie.

| | | | | | |
|---|---|---|---|---|---|
| Australia | 1 | Africa | 4 | Asia | 5⅚ |
| Europe | 1½ | America | 4⅔ | | |

In the projection of the sphere upon the plane of the horizon of London, the globe is divided into almost a terrestrial and an oceanic hemisphere ; London, therefore, occupies nearly the centre of the terrestrial hemisphere, and consequently of the commercial world.

## II. *The Great Oceans.*

The waters of the ocean form one continuous fluid, covering nearly seven-tenths of the surface of the globe. It will be seen that the continents determine the general outlines of the great ocean basins. The indentations of their coasts give the articulation of the border of the oceans ; the islands, by their position, and by their less or greater frequency, give what else is wanting to complete the outline: the figures of the land are the counterpart of that of the ocean ; they are the same forms, contemplated in an inverse order. By the formation of the five continents, the ocean waters are divided into five large portions, namely, the Pacific, Atlantic, Indian, and two Polar Oceans. These large masses of water send off arms or branches into the interior of the land which receive the name of inland seas. The smaller arms are generally termed *bays* and *gulfs*. The great oceans, with their principal branches, are as follow :—

*The Pacific Ocean.*—This mighty expanse of water, which extends over about 145° of longitude, is enclosed between America on the east, and Asia, the islands of Sumatra, Java, and Australia on the west. The Antarctic Ocean bounds it on the south, and Behring's Strait on the north. It is divided by the equator into the North and South Pacific.

This *Great Ocean*, as it has been very justly named, spreads out from north to south, separating its coasts far asunder, and sometimes encroaching in broad gulfs upon the low-lying lands of Asia. In appearance it has rather a compact form with numerous islands, many of which are of volcanic origin, scattered over its surface. Its narrowest part, the Sea of Kamtschatka, has a breadth of only 170 miles, but its greatest breadth from east to west, measured along the equator, is above 12,000 miles. Its area, which exceeds the superficies of all the dry land on the globe, is more than 50 millions of square miles.

The shape of this ocean is somewhat that of an oval; though wide open on the south, its sides gradually approach each other towards the north. It seems, moreover, to be an immense sunken basin, the broken and elevated edges of which present on all sides the abrupt terminations of the continents. From this compact mass of waters no less than five large and nearly land-locked seas succeed each other along the eastern shores of the Asiatic continent, namely, the Sea of Behring, closed in by the peninsula of Aliaska, and the chain of the Aleutian Islands; the Sea of Okotsk, enclosed by the peninsula of Kamtschatka, and the series of the Kurile Islands; the Sea of Japan, shut in by the island chain of this name; the Northern Chinese Sea, locked by the islands of Lieu-Khieu and Formosa; the Southern Sea of China, locked by the Philippines, Borneo, and the peninsula of Indo-China. We may almost call the Vermilion Sea, or Gulf of California, an inland sea; this, with the Gulf of Panama, are the only indentations of this ocean on the American coast.

*The Atlantic Ocean* commences in the south at the Antarctic circle, and terminates in the north at the Arctic circle. The equator divides it into the North and South Atlantic.

This ocean, which seems to be a simple depression, or valley, somewhat in the form of a trough, maintains in its bed, from north to south, a certain parallelism, penetrating by several arms into its northern coast lands, and forming inland seas with narrow inlets: few island groups appear about the interior of its basin. Where narrowest, between Greenland and Norway, it is about 930 miles across, but between North Africa and Florida, where it attains its greatest breadth, the distance from shore to shore exceeds 4,150 miles. Its superficial area is about 25 millions of square miles. Though it comprises little more than one-fifth part of the whole ocean, its shores form a more extended coast line than those of all the other seas taken together. This arises from the several extensive Mediterranean Seas which it sends off, and which pierce into the very centre of the Old World and the New. Omitting the Polar Seas, there are at least four Mediterraneans, two on the European side, namely, the Baltic and the Mediterranean properly so called, with its three great basins, the Eastern, the Western, the Black Sea, and numerous others of small size. On the coast of the New World there are two Mediterraneans, the Gulf of Mexico and Hudson's Bay. Its land-locked seas are the Northern Ocean, on the coast of the Old World; the Caribbean Sea, in Central America, closed by the peninsula of Yúcatan and the chain of the Greater and Lesser Antilles; and the Gulf of St. Lawrence, locked by the peninsula of Nova Scotia and Newfoundland.

From the fact that the Atlantic is the most articulated and indented of the oceans, it is said to be the most *maritime*, as the Pacific is the most truly *oceanic*.

*The Indian Ocean* has the form of a triangle, the vertex of which is turned to the north. Its boundaries are, Africa on the west; Arabia, Persia, and Hindoostan on the north; the islands of the East Indian Archipelago and Australia on the east; and the Antarctic Ocean on the south. Its branches are the Red Sea and Persian Gulf, two Mediterranean seas which detach the peninsula of Arabia from the rest of the continent, and the Bay of Bengal.

Like the Great Pacific, this ocean is land-bound on the north, and its coasts diverge in a southern direction; but it resembles the Atlantic in its encroachments upon its northwestern shores, and in the small straits through which its waters flow in upon the land. Its length and breadth are each about 4,500 miles, and its area about 20 millions of square miles.

*The Arctic* or *North Polar Ocean* surrounds the North Pole, and is bounded by the northern shores of the continents of Asia, Europe, and America. Its branches are, the White Sea, Sea of Kara, and the Gulf of Obi. On all sides it is nearly land-locked, and is limited in its communication with the Pacific and Atlantic. The diameter of its basin is about 2,400 miles.

*The Antarctic* or *South Polar Ocean* is included between the Antarctic circle and the South Pole, and is without land boundaries, its waters freely circulating through the two great oceans. Little is known of this immense basin; its navigation is in many parts impeded by impenetrable barriers of ice.

Each ocean, therefore, differs from the others in some peculiarities of character; and we readily conceive how these circumstances may modify their importance with regard to the facility or the difficulty they may bring into the relations of exchange which commerce establishes among all the nations of the world.

# CHAPTER IV.

## MAP II.

### FORM OF THE GREAT CONTINENTS.

THE appearances presented in the structure and arrangement of the materials of which the land is composed indicate that it has undergone, at successive periods, mighty revolutions. These changes have been produced by the agency of heat and water, acting separately from each other; or by the irresistible force which results from their contact. These elements are constantly effecting alterations in the surface and coast-line of the land,—the one by subterranean energy, as exhibited in the upheaving and fracturing action of the earthquake, the other by the agency of running streams upon the land and the motions of the ocean waters, as exemplified in the formations continually going on at the mouths of large and sluggish rivers, in the wearing action of the sea-wave, and in the tidal movements and currents of the ocean.

The operation of these elements—to which must be added that of the atmosphere and of the electricity contained in it—has been so gradual that, during a period of even thousands of years, they have but slightly altered the general features of the land-masses of the globe. It is, therefore, not improbable that the land now maintains the form which it presented when the waters of the deluge subsided from its surface.

Upon examining what is termed the *horizontal profile* of the land, we observe that, though the waters of the ocean have worn the coast-line of the land into numerous gulfs and inlets, it is, nevertheless, remarkable that the continents preserve in their general outline a certain triangular form: this is very striking in the shape of North and South America, Africa, and in the limbs of Asia and Europe.

It is also a remarkable circumstance that the greatest extension of the continents towards the north and south is nearly under the same meridian: this will be evident in comparing the Cape of Good Hope with the North Cape of Europe, the peninsula of Malacca with Cape Taimura in Siberia, and Cape Horn with the north-western part of Baffin's Bay and of the great Polar-land.

The continents, with the exception of Africa, present to

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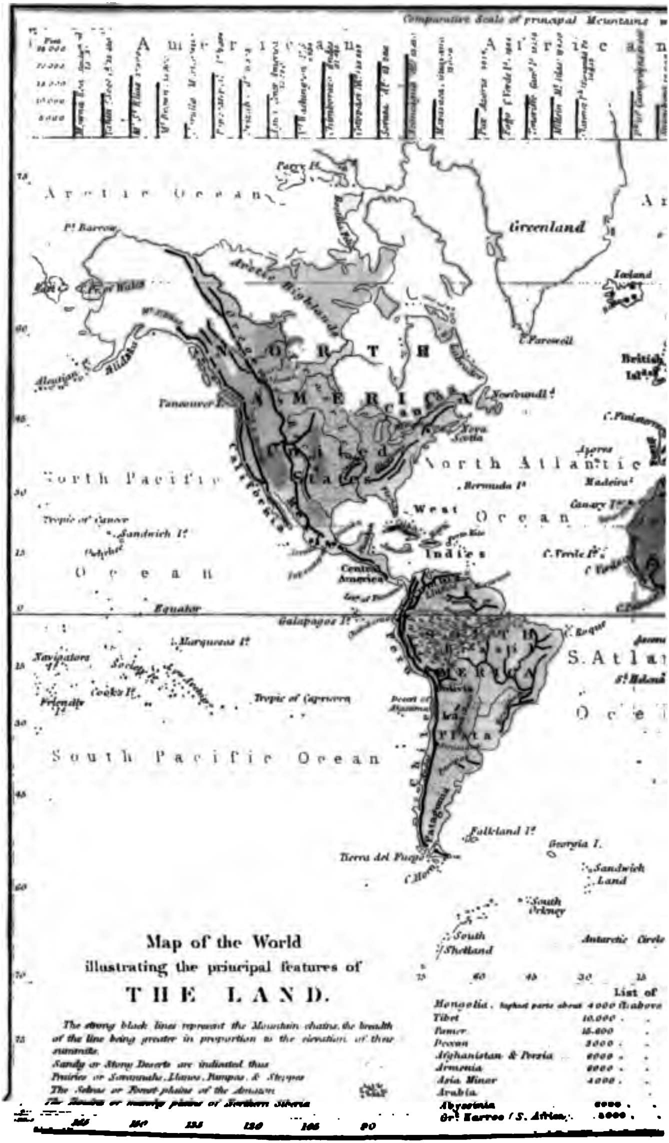


## Map of the World illustrating the principal features of THE LAND.

*The strong black lines represent the Mountain chains, the breadth of the line being greater in proportion to the elevation of their summits.*

*Sandy or Stony Deserts are indicated thus*

*Prairies or Savannahs, Llanos, Pampas, & Steppes*

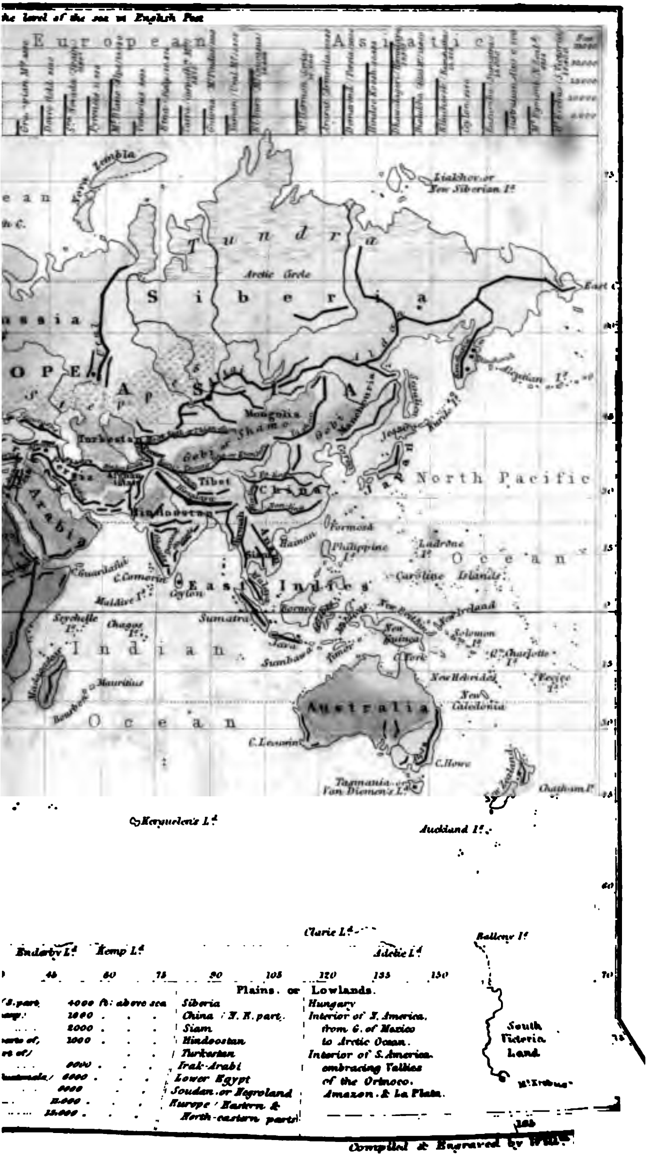
*The Selvas or Forest-plains of the Amazon*

*The Tundras or marshy plains of Northern Siberia*

List of

*Mongolia*, highest parts about 4000 ft. above
*Tibet* 10,000
*Pamer* 15,000
*Deccan* 2000
*Afghanistan & Persia* 6000
*Armenia* 6000
*Asia Minor* 4000
*Arabia*
*Abyssinia* 6000
*Gr.t Karroo (S. Africa)* 3000

London:



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the sea on their northern sides broad flats of low-lying land, whilst the southern coasts are rocky, pointed, and elevated. The latter portion of this remark holds good with respect to all the great land-masses, as Europe, Asia, and Australia, —each of which terminates in three points towards the south,—while America and Africa contract towards the same direction into single promontories.

The coasts of the land situated in the northern hemisphere appear the most indented, the currents of the Pacific having worn the eastern shores of Asia into several gulfs and peninsulas. The north-eastern shores of America present a broken and irregular coast line: this results from the influence of the North Atlantic, whose powerful currents have invaded the land, and found resistance only in the West Indian Islands, as the Pacific has done in the East Indian Archipelago.

The coast line of Europe is deeply jagged and broken; its shores stand in bold contrast with the continents of Africa, South America, and Australia, that stretch into the southern hemisphere. This circumstance not only affects its climate and productions, but tends very materially to promote civilization and commerce.

The fact that nearly all the large promontories stretch in a southerly direction is worthy of remark. In the Old World, instances of this occur in the peninsulas of Scandinavia, Italy, Greece, Africa, Arabia, Hindoostan, Malacca, Corea, and Kamschatka; and in the New World examples are afforded in Greenland, Nova Scotia, Florida, California, and South America. The exceptions to this law are the peninsulas of Yúcatan in central America, and Jutland in Europe, both of which point northward, and the peninsulas of Aliaska in Russian America, and Cotentin in France, which lie in a westerly direction.

The peninsula of Florida and the West Indian Archipelago strikingly resemble the Malayan peninsula and the East Indian Archipelago. Again, the limbs of Asia, though on a more gigantic scale, somewhat resemble those of Europe. Thus the Arabian peninsula corresponds to the Iberian; the Indian peninsula with Ceylon to Italy with Sicily; extreme India with its Archipelago to Greece with its Archipelago. The eastern shores of Asia, which, broken by the force of the currents of the ocean, exhibit a richly variegated configuration, peninsulas and contiguous islands alternating from the equator to 60° north latitude. The large gulfs which extend from Tonquin to the northern shores of America exercise a *modifying influence* upon the climate, and *consequently upon the productions*, of eastern Asia.

The configuration of Africa and South America presents something striking to the imagination, the projection of the one corresponding to the indentation of the other; for instance, the north-western part of Africa seems to fit into the Gulf of Mexico, and the north-eastern portion of South America dovetails, as it were, into the Gulf of Guinea.

Ritter was the first to bring prominently forward the difference which exists between the continents with regard to the lengths of their coast lines. Some are deeply indented, furnished with peninsulas, gulfs, inland seas, which give to the line of their coasts a great length. Others present a mass more compact and undivided; their trunk is, as it were, deprived of members. The line of their coasts, being more simple and without numerous inflections, is comparatively much shorter.

Considered under this aspect, the three continents of the Old World form a striking contrast. Africa is the most simple in its forms. Its mass—nearly round or ellipsoidal—is concentrated upon itself. It projects no important peninsula into the ocean, nor anywhere lets the ocean waters into its interior. It seems to close itself against every influence from without. Thus the extension of the line of its coasts is only 14,000 geographical miles, of 60 to the degree, for a surface of 8,720,000 square miles; so that Africa has only 1 mile of coast for 623 miles of surface.

Asia, although washed on three sides only by the ocean, exhibits, especially on its eastern and southern coasts, large peninsulas, as Arabia and the two Indies, Corea and Kamschatka. Whole countries are pushed out into the ocean, as Mandchouria and China: nevertheless, the extent of this continent is such that, notwithstanding the depth of the indentations, there yet remains at its centre a great mass of undivided land, which commands the maritime regions, as the body commands the limbs. Asia is indebted to this configuration for a line of coast of 30,800 miles: it is double that of Africa, which is only one-third smaller. Asia, therefore, possesses a mile of coast to 459 square miles of surface. Of all the continents, Europe presents the most varied forms of contour. Its principal mass is deeply cut in all parts by the ocean and by inland seas, and seems almost on the point of resolving itself into peninsulas. Two of its large peninsulas, namely, Greece and Scandinavia, repeat to infinity the phenomena of articulation and indentation of coasts which are characteristic of the entire continent. The line of the shores of the whole continent extends to about 17,200 miles, an enormous proportion compared with its small size; for it is 3,200 miles more than Africa, which is, nevertheless, three times greater. Europe enjoys one mile of coast for every 156 square miles of surface. It is thus the continent most open to the sea for foreign intercourse, at the same time that it is the richest in local and independent districts.

In this regard, therefore, there is a sensible gradation between the three principal continents of the Old World. Africa is the most simple; it is a body without members, a tree without branches. Asia is a mighty trunk, the numerous members of which, however, make only one-fifth of its mass. In Europe the members overrule the principal body, the branches cover the trunk; the peninsulas form almost a third of its entire surface. Africa is closed to the ocean; Asia opens only its margins; Europe is deeply penetrated by it, and is thereby the most accessible of all the continents.

America repeats the same contrasts, though not in an equally striking manner. North America, like Europe, is more indented than South America, the configuration of which, in the exterior at least, reminds us of the forms of Africa and the uniformity of its coast-line. The two continents of the New World are more alike, but the line of the shores is much more extended in North than in South America. It is 24,000 miles in the former, or 1 mile of coast to 228 square miles of surface; in the latter it is 13,600 miles, or 1 mile of coast for 376 miles of surface.

The following table represents these differences of configuration of the continents by numerical proportions. The mile here employed is the geographical mile, of 60 to the degree:—

| CONTINENTS. | Surface in Square Miles of 60 to a Degree. | Length of Line of Shores. | Square Miles for 1 Mile of Coast. |
|---|---|---|---|
| Europe - - - - - | 2,688,000 | 17,200 | 156 |
| Asia - - - - - - | 14,128,000 | 30,800 | 459 |
| Africa - - - - - | 8,720,000 | 14,000 | 623 |
| Australia - - - - | 2,208,000 | 7,600 | 290 |
| North America - - - | 5,472,000 | 24,000 | 228 |
| South America - - - | 5,136,000 | 13,600 | 376 |

The land in its *vertical profile* exhibits a great variety of aspects; but it may be observed that all the continents rise gradually from the shores of the seas towards the interior, to a *line of maximum elevation* of the masses: the *similarity of feature existing between* Europe and Asia is as remarkable as the great dissimilarity between the surface of the African and American continents. The great chain of mountains comprising the Pyrenean and Alpine ranges, with their offshoots, corresponds to the mountain masses of Taurus, Caucasus, and the Himalaya. In both continents a great lowland stretches northward from the bases of these elevated ridges. The basin of the Lower Danube has its counterpart in Tonquin, and other parts of European Turkey correspond to the peninsula beyond the Ganges; whilst the immense basin of the Ganges exactly resembles, in formation, that of Venetian Lombardy. The Alpine masses and those of the Hindoo Koosh offer precisely similar clefts in their *cols* or mountain passes. These defiles have in both instances been the arteries of commerce, and the corresponding localities into which they lead have for ages been the seats of civilization and power. Delhi, says M. Boué, is Milan. Calcutta reminds us of Venice; whilst Bombay is the counterpart of Genoa.

As the external configuration of continents, which we have already described, in their horizontal expansion, exercises by their variously indented littoral outlines a favourable influence on climate, trade, and the progress of civilization, so likewise does their internal articulation, or the vertical elevation of the soil (chains of mountains and elevated plateaus), give rise to equally important results. Whatever produces a diversity of forms on the surface of our planet, such as mountains, lakes, grassy savannahs, or even deserts, encircled by a band of forests, impresses some peculiar character on the social condition of the inhabitants. Ridges of high land covered by snow impede intercourse; but a blending of low discontinued mountain chains and tracts of valleys, as we see so happily presented in the west and south of Europe, tends to the multiplication of meteorological processes and the products of vegetation, and from the variety manifested in different kinds of cultivation in each district, even under the same degree of latitude, gives rise to wants that stimulate the activity of the inhabitants. Thus the awful revolutions during which, by the action of the interior on the crust of the earth, great mountain chains have been elevated by the sudden upheaval of a portion of the oxidised exterior of our planet, have served after the establishment of repose, and on the revival of organic life, to furnish a richer and more beautiful variety of individual forms, and in a great measure to remove from the earth that aspect of dreary uniformity which exercises so impoverishing an influence on the physical and intellectual powers of mankind.

# CHAPTER V.

## FEATURES OF THE LAND.

THE surface of the land, as well as its coast line, presents very great variety, exhibiting numerous elevations and depressions, which are termed *highlands* and *lowlands*. In some places the land is merely undulating; in others it is rugged, precipitous, and irregular. The highlands of the whole earth exceed the lowlands by about one-sixth part. Africa contains more highland than any of the other continents, and Europe (in proportion to its size) more of flat lowland.

Africa and Asia together contain the largest portion of elevated land, and Europe and America of lowland.

Since grand and lofty mountain chains so strongly excite our imagination by the evidence they afford of great terrestrial revolutions, and when considered as the boundaries of climates, as lines of separation for waters, or as the site of a different form of vegetation, it is the more necessary to demonstrate by a correct numerical estimation of their volume, how small is the quantity of their elevated mass when compared with the area of the adjacent continents. The mass of the Pyrenees, for instance, the mean elevation of whose summits, and the areal quantity of whose base have been ascertained by accurate measurements, would, if scattered over the surface of France, only raise its mean level about 115 feet. The mass of the eastern and western Alps would in like manner only increase the height of Europe about 21 feet above its present level. "I have found," says Humboldt, "by a laborious investigation, which from its nature can only give a maximum limit, that the centre of gravity of the volume of the land raised above the present level of the sea in Europe and North America is respectively situated at an elevation of 671 and 748 feet, while it is at 1,132 and 1,152 feet in Asia and South America. These numbers show the low level of northern regions. In Asia the vast steppes of Siberia are compensated for by the great elevations of the land (between the Himalaya, the North Thibetian chain of Kuen-lun, and the Celestial mountains), from 28° 30′ to 40′ north latitude. We may to a certain extent trace in these numbers the portions of the earth, in which the plutonic forces were most intensely manifested in the interior, by the upheaval of continental masses."

### I. *Elevated Land of the Great Continents. Mountains.*

*Configuration.*—Mountains are the most considerable elevations of the surface of the earth, and are generally arranged in *groups*, *ranges*, and *chains*. All eminences whose height exceeds 1,000 feet are regarded by most geographers as *mountains*, and those of less altitude as *hills*. Mountains rarely occur solitary in plains, and remote from other masses: those that have been observed so situated are for the most part either active or extinct volcanos.

Among the most striking examples of *insulated* mountains are, the Peak of Teneriffe, the Rock of Gibraltar, the Fortress of Gwalior, in Hindoostan, and Mount Egmont, in New Zealand

*Chains and Systems.*—When mountains or hills are connected together by a continued base, and so disposed as to form a line or belt, whose length greatly exceeds its breadth, whatever direction the band may take, or whatever shape it may assume, that of a straight line, angle, or curve, such an arrangement is said to constitute a *chain*, and a series of these chains is called a *system*. The term chain is not meant to signify an uninterrupted line of projections, but a range of eminences varying in height, in many cases detached, yet lying so manifestly in the same *general direction* as to indicate a continuous base.

Several chains may be resolved into three nearly parallel ranges, the highest occupying the centre; the lateral ranges are of less elevation in proportion to their distance from the central mass, and gradually diminish in height till they are lost in the general surface of the adjacent plain. From the principal mass, extensive and lofty branches diverge at different angles, and these again send off shoots or spurs, which sink and merge into the surrounding lowlands. The point of greatest elevation of a principal range is usually about the middle, and the highest parts of a branch range at the points of junction with the parent stem

*Form and Aspect.*—The form of mountains is altogether dependent upon their geological structure. According to their supposed resemblances, they are called *needles*, *peaks*, *teeth*, *domes*, *forks*, *horns*, &c. Some stretch along like a vertical wall, their summits presenting the appearance of ruined battlements and towers, others again seemed piled on each other, forming a gigantic succession of steps or terraces. Insulated mountains vary in form, but those of volcanic origin are generally conical.

The distance from which particular mountains may be seen depends not only upon their height, but upon the nature of their projections and the conditions of the atmosphere. They present every variety of outline as the observer approaches or recedes from them: at a distance the minute irregularities are lost in the general outline, and different colours become blended into a uniform hue.

*Composition.*—Granite is supposed to form a vast connected vault, upon which are supported all the masses of matter which constitute the crust of the earth. It forms the most elevated portions of the continents in the eastern hemisphere, and, when exposed, presents lofty and rugged elevations. The highest mountains are composed of granite, gneiss, mica, slate, and quartz. In this respect there is a remarkable difference noticed by Humboldt between the old and new continents. In the former, the highest points of the Alps consist of granite; but in the latter, granite is not found higher than 12,000 feet above the level of the sea. Vast walls of porphyry crown Antisana and Chimboraço, and basalt forms the very summits of Pichincha. The newest whinstone, which, in Europe, appears only in low mountains, or at the foot of those of great magnitude, covers the tops of the Andes. Other secondary formations are found at greater heights in the new than in the old world.

*Slope or Declivity.*—The declivities of mountains are observed to be either long and gentle, or steep and abrupt. The greater number of the principal chains have one of their sides very steep, and the other of a gradual slope. The Alps are much more rapid in their descent on the Italian side than on that of Switzerland. The Scandinavian chain has a much steeper declivity on the west and north-west than towards the east and south. The Pyrenees, the Sierra-Morena, in south Spain, and the Alpuxarras, near Granada, have their steepest sides towards the south. The Atlas mountains and Mount Libanus present bold and craggy declivities to the Mediterranean. The Himalaya chain exhibits a steep face to the Indian Ocean, and long gentle slopes towards the north. The Ghauts (Ghâts), in the peninsula of Hindoostan, have precipitous sides towards the sea, and sloping declivities inland. The two last-*mentioned chains* seem to be the abrupt borders of the long upland plains which they respectively enclose namely, the Plateau of Tibet and the Plateau of the Deccan. With regard to the slope of mountain chains, we must consider it as the inclination of a line supposed to be drawn from their summits to the plain: the angle included between this line and the mean level of the plain varies from 2° to 6°; the northern slope of the Pyrenees is from 3° to 4°, and the southern slope of the high Alps from the general summit line to the plains of Piedmont and Lombardy is about 3¾°.

Sometimes, in a general range, individual mountains rise abruptly from the adjacent valleys; when their slope exceeds 7° or 8° they cannot be ascended by carriages. An inclination of 15° or 16° would be considered very steep for beasts of burden. A mountain having an inclination of 35° could not be climbed even by cutting steps. Upon the slope of mountain chains and plains depend the drainage of the land and the direction of rivers.

In all the continents the line of greatest elevation in the summit of ascent is placed out of the centre, on one of the sides, at an unequal distance from the shores of the seas, from which result two slopes, unequal in length and in inclination. This is analogous to what, in mountains, is called the slope and the counter slope.

The length of these two inclined planes, estimated approximately and in round numbers, is nearly as follows. The first column indicates the length in geographical miles of the long slope, the second that of the short one.

OLD WORLD.

| | Length in Miles. | |
|---|---|---|
| | Northern Slope. | Southern Slope. |
| 1. *Eastern Asia.* | | |
| The section begins at the Frozen Ocean at the mouth of the Yenesei, and terminates in the Plains of the Ganges. The culminating region is that of the table-lands of Thibet and of the Dhawalagiri, which divides this line into two slopes - - - - - - | 2,600 | 400 |
| 2. *Western Asia.* | | |
| From Lake Aral and the Plains of the Caspian Sea to the Persian Gulf; culminating point, *the coast chain of* the Persian Gulf - - | 900 | 80 |

| | Length in Miles. | |
|---|---|---|
| | Northern Slope. | Southern Slope. |
| 3. *Western Asia.* | | |
| From the Plains of Georgia to those of the Euphrates; culminating point, the high chains of Kurdistan - - - - - - | 260 | 80 |
| 4. *Asia Minor.* | | |
| From the northern to the southern coast, nearly on the meridian of Cyprus; culminating point, the chain of Taurus - - - - | 300 | 50 |
| 5. *Central Europe.* | | |
| From the shores of the Baltic to the Plains of Lombardy; culminating point, the Tyrolean Alps - - - - - - - - - - | 450 | 100 |
| 6. *Africa.* | | |
| From the mouth of the Nile to the Cape of Good Hope; culminating point, probably the high plateaus between the sources of the Zambezi and of the Orange river - - - | 3,300 | 600 |

NEW WORLD.

| | Length in Miles. | |
|---|---|---|
| | Eastern Slope. | Western Slope. |
| 1. *North America.* | | |
| From Washington to the Bay of St. Francisco; culminating point, the central chain of the Rocky Mountains - - - - - - | 1,600 | 800 |
| 2. *Central America.* | | |
| From Porto Rico through Mexico to the Pacific Ocean, the line slightly broken to take in the Great Antilles; culminating point, the plateau of Mexico - - - - - - | 2,000 | 300 |
| 3. *South America.* | | |
| From the mouth of the Amazon through the table-land of Peru to the Pacific Ocean; culminating point, the Chimboraço - - | 1,850 | 70 |
| 4. *South America.* | | |
| From the coasts of Brazil, North of Rio Janeiro, through the Lake of Titicaca to the Pacific; culminating point, the Nevada de Sorata - | 1,600 | 200 |

From the data contained in these tables are deduced the following general facts.

In the Old World the long slopes are turned towards the north, and the short slopes towards the south. In the New World the gentle slopes descend towards the east, and the short and rapid slopes towards the west. Thus, in this respect, each of the two worlds has a law peculiar to itself.

In each, the two laws exert their influence. In the Old World, though the principal slope is towards the north, we observe still a gradual decrease of the reliefs from east to west; in the same manner, in the New World, the principal slope is from the west to the east, but it can be seen that the reliefs go on gradually increasing from north to south, as in the Old World. In these two secondary directions of the reliefs we discover the law of the unequal slopes; in the Old World the long slope descends to the west, the short slope to the east; in the New World the long slope is to the north, the short to the south.

In short, a common law combines in a single great fact all we have just said upon the general reliefs of the continent; it may be thus expressed:—All the long and gentle slopes descend towards the Atlantic and towards the Frozen Ocean, which is only a dependence of it; all the short and rapid slopes, or counter slopes, are directed towards the Pacific Ocean, and towards the Indian Ocean, which is its continuation.

*Elevation.*—Though mountains appear to be enormous protuberances upon the earth's surface, they are very inconsiderable when compared with the whole mass of the globe. The highest, Dhawalagiri, which attains an elevation of more than five miles above the level of the sea, is only about one eight-hundreth part of the earth's radius. They may therefore be compared to the little risings (papillæ) on the rind of an orange.

The height of mountains is a subject of great importance in physical geography, since elevation determines climate. Mountains, therefore, placed between the tropics, whose summits rise above the snow line, exhibit every variety of climate, and consequently the *habitats* and *stations* of various plants and animals. On the upper margin of Map II. are given the names and height in feet of the principal mountains upon the surface of the globe, their comparative heights being indicated by faint horizontal lines; and at the end of this book will be found a Table containing the mountain chains, with the height of their culminating points in English feet.

The law of increase of reliefs is common to the mass elevations, and to the linear elevations; that is, the height of the lowlands and of the table-lands increases at the same time with the absolute elevation of the mountains. This law is exhibited by the following table.

The first column contains the height of the plateaus, the second that of the highest corresponding peaks, both in English feet.

OLD WORLD.—*North to South.*

| | Low-lands and Table-lands. | Highest Mountains. |
|---|---|---|
| 1. *Eastern Asia.* | | |
| Coast of the Frozen Ocean, mouth of the Yenesei | – | – |
| Plains of Siberia, Barnaul, foot of the Altai Mountain | 380 | – |
| Altai, Bjelucha | – | 11,000 |
| Dzoungary, Lake Saisan | 1,300 | – |
| Thian-Shan Chain Bogdo-oold | – | 19,000 |
| Eastern Turkestan, Desert of Lop | 2,000 | – |
| Northern basis of the Kuenlun | 5,000 | – |
| Chain of Kuenlun | – | 22,000 |
| Katschi Plateau | 11,000 | – |
| Plateau of Tibet | 14,000 | – |
| Dhawalagiri | – | 28,000 |
| Benares, Plains of the Ganges | 250 | – |
| 2. *Western Asia.* | | |
| Lake Aral, Plains of the Caspian Sea | – | – |
| Foot of the table-land | 500 | – |
| Atak-chan, Kabuskan | – | 4,000 |
| Table-land of Khorassan | 2,000 | – |
| Ispahan | 4,400 | – |
| Shiraz | 4,500 | – |
| Tengi-Firesan, coast chain | – | 9,000 |
| Coast of the Persian Gulf | – | – |
| 3. *Western Asia.* | | |
| Tiflis, Plains of Georgia | 1,160 | – |
| Pambak, chain | – | 7,000 |
| Ararat, the plain around | 2,800 | – |
| Ararat, Mountain | – | 17,000 |
| Ala dagh | – | 10,000 |
| Lake Van | 5,400 | – |
| Djudid Dagh | – | 12,000 |
| Mossul | 350 | – |
| Euphrates, the plains | 200 | – |

| | Low-lands and Table-lands. | Highest Mountains. |
|---|---|---|
| 4. *Asia Minor.* | | |
| Crimea, Tchatur Dagh - - - - - - | - | 5,000 |
| Black Sea - - - - - - - - | - | - |
| Chains along the the coast of Asia Minor - | - | 5,000 |
| Table-land, Amasia - - - - - - | 1,200 | - |
| Kaisarieh, table-land - - - - - - | 3,000 | - |
| Erdshish Mountain - - - - - - | - | 13,000 |
| Taurus Chain, Bulghar Dagh - - - - | - | 10,000 |
| Coast of Cilicia - - - - - - - | - | - |
| Cyprus, Stavro-Vouno peaks - - - - | - | 10,000 |
| 5. *Central Europe.* | | |
| The coast of the Baltic Sea - - - - - - | - | - |
| Plains of North Germany, Berlin - - - | 100 | - |
| The Hartz, Brocken - - - - - - - | - | 3,700 |
| Thuringerwald - - - - - - - - - | - | 3,200 |
| Carpathian Mountains, Satra - - - - | - | 9,500 |
| Table-land of Franconia - - - - - | 800 | - |
| Table-land of Bavaria, foot of the Alps - - | 2,100 | - |
| The Alps, the Glockner - - - - - - - | - | 12,800 |
| Plains of Lombardy - - - - - - | 200 | - |
| 6. *Africa.* | | |
| Mediterranean Sea, Mouth of the Nile - - | - | - |
| Plains of Cordofan - - - - - - - - | 1,200 | - |
| Table-lands at the Zambezi - - - - - - | 5,000 | - |
| Lupata chain - - - - - - - - - | - | 11,000 |
| Nieuwvelt Mountains - - - - - - - | - | 9,000 |
| Great Karroo - - - - - - - - - | 2,700 | - |
| Zwarteberge - - - - - - - - | - | 5,000 |
| Coast - - - - - - - - - - - | - | - |
| 7. *India. Deccan.* | | |
| Plains of the Ganges, Delhi - - - - - - | 800 | - |
| Aravulli Mountains - - - - - - - | - | 5,000 |
| Table-land of Deccan, Punah - - - - | 1,800 | - |
| Mysore - - - - - - - - - - | 2,700 | - |
| Nilgherries - - - - - - - - - | - | 8,800 |
| Travancore Mountains - - - - - - | - | 7,500 |
| Palamcotta - - - - - - - - - | 300 | - |
| Cape Comorin - - - - - - - - - | - | 500 |
| 8. *Arabia.* | | |
| Mouth of the Euphrates - - - - - - - | - | - |
| Inner Arabia, Nedjed, table-land - - - | 2,000 | - |
| Yemen, Sana - - - - - - - - - | 5,000 | - |
| Djebel Yafai - - - - - - - - - | - | 6,600 |
| *Aden, Coast* - - - - - - - - - | - | - |

The same law exists in the great peninsulas of Asia, whose basis is a table-land, and which are almost small continents, as India and Arabia. In those of Europe, which are smaller and more irregular, the law is not expressed; yet the Taygetus in Greece, and the Sierra Nevada in Spain, belong to the highest summits of the three peninsulas.

New World.—*East to West.*

| 1. *North America.* | Low-lands and Table-lands. | Highest Mountains. |
|---|---|---|
| Washington | – | – |
| The Great Valley of Virginia | 300 | – |
| Apallachian Mountains | – | 6,000 |
| Mississippi Valley, St. Louis | 500 | – |
| Mouth of the Kansas | 800 | – |
| Foot of the Rocky Mountains, Fort St. Vrain | 5,000 | – |
| Spanish Peaks | – | 12,000 |
| Plateau of Inner California | 6,000 | – |
| Wind-river Mountains | – | 13,500 |
| Fremont Basin | 4,300 | – |
| Sierra Nevada, of California | – | – |
| Shastl Peak | – | 14,000 |
| St. Elias Peak | – | 17,800 |
| Nueva Helvetia | 40 | – |
| Pacific Ocean | – | – |
| 2. *Central America.* | | |
| Porto Rico | – | 3,500 |
| Haiti | – | 5,000 |
| Cuba | – | 7,000 |
| Jamaica, Blue Mountains | – | 7,500 |
| Table-land of Mexico | 7,500 | – |
| Coffre de Perote | – | 13,000 |
| Popocatepetl | – | 19,000 |
| Plateau | 3,000 | – |
| Colima Volcano | – | 9,000 |
| Pacific Ocean | – | – |
| 3. *South America.* | | |
| Mouth of the Amazon | – | – |
| Sierra Parime, Acarai | – | 4,000 |
| Sierra Parime, Duida | – | 8,400 |
| Foot of the Andes | 1,000 | – |
| Volcano of Cayambe | – | 19,600 |
| Quito | 9,600 | – |
| Chimboraço | – | 21,400 |
| Pacific Ocean | – | – |

| 4. *South America.* | Low-lands and Table-lands. | Highest Mountains. |
|---|---|---|
| Coast of Brazil - - - - - - - - - | – | – |
| Table-land of Brazil - - - - - - - - | 2,000 | – |
| Itambe, Sierra de Espinhaco - - - - - | – | 6,000 |
| Sta. Cruz de Rio Grande - - - - - - | 1,000 | – |
| Nevada de Sorata - - - - - - - - | – | 25,300 |
| Lake of Titicaca - - - - - - - - | 12,800 | – |
| Volcano of Arequipa - - - - - - - | – | 18,300 |
| Coast of the Pacific - - - - - - | – | – |

*Direction of Mountain Systems.*—The grandest features of the continental masses are unquestionably their immense mountain ranges: these are observed to lie in all possible directions, both as regards the points of the compass and the trending of the coast lines. In some places they are detached, and in others arranged in simple or connected chains. In one place they run in parallel directions, in another intersect or branch off at different angles. In one country the mountains are set like a knot in its centre, whilst in another they are placed near the coast line. Though in their course they are observed to make numerous curves and angles, yet their *general direction* most commonly corresponds with the greatest length of the larger land-masses. This is apparent in the vast mountain chain which traverses the American continent, and in the Scandinavian Alps, the Apennines, and the Ghauts, which follow the direction of their respective peninsulas.

Generally speaking, the reliefs go on increasing from the poles to the tropical regions. The highest elevations, however, are not placed at the equator, but in the neighbourhood of the Tropic of Cancer in the Old World, and near the Tropic of Capricorn in the New.

Buffon was the first to remark that the principal mountain chains of the Old World follow the direction of the parallels, and those of the New World the direction of the meridians, and that the secondary chains follow the inverse in both.

If therefore we arrange the mountains on the globe into two great classes, namely, those that run nearly parallel to the equator, and those that pursue the direction of the meridians, we observe by inspection of the Map that the former are the more important, and that they become more numerous as they approach the equatorial regions. That broad belt of chains of the first magnitude, which runs from east to west, and includes the central ranges of Asia and Africa,—the ranges of the Atlas and the Alps,—the coast chains of New Grenada and of Parime, with the submarine ridges of Oceanica, whose summits just emerge above the surface of the ocean, exemplify this remark.

From the fact of there being little known of the interior of Australia, we are not enabled to remark upon the general features of that vast portion of land; but from its sandy far-extending coast flats, the absence of rivers upon its western and northern coasts, the proximity of its mountains to its eastern and southern shores, and other phenomena connected with its structure, we are led to conclude that the interior is not occupied by table-lands or elevated chains, whilst, from the parching winds that blow from its central regions, we conclude that it is not furnished with numerous ponds or lakes.

We have said that the mountain systems follow the direction of the greatest length of the continents. In the Old World they commence at Behring's Strait, on the north-eastern shores of Asia, under the name of the Aldan Mountains; from these a branch called the central mountains shoots off into Kamtschatka. To the Aldan Mountains succeed the Yablony or Stanovoi Mountains, which run in a south-westerly direction as far as the 120th meridian. They then break up into several chains which enclose on all sides the central table-land of Asia. The range on the eastern side of this highland bears the name of the Khing-shan on its northern part, the In-shan in the centre, and the Yung-ling in the south. From this range two others diverge, and run through China Proper from west to east, under the names of the Pe-ling and the Nan-ling Mountains.

Four great chains traverse central Asia from east to west, namely, the *Altai* which borders the great plateau on the north; the Thian-shan or Celestial Mountains, and the Kuen-lun, which are supported upon its surface; the Himalaya forms its southern boundary, and constitutes the loftiest system on the globe. On the western side the great table-land is fringed by the Beloor-tágh Mountains.

These various chains seem to unite in a group or knot of mountains, called the Hindoo Koosh, about the 35th parallel and the 73rd meridian. Proceeding westward, this chain breaks up into several distinct ranges which surround the upland plains of Persia and Afghanistán, or the plateau of

Iran. This highland is bordered on the east by the Suleymán and the Hala Mountains, and on the west by the mountains of Zagros. A broken and irregular range of heights, known as the Paropamisan Mountains, runs along the northern declivity of this plateau until it reaches the shores of the Caspian Sea, which is bounded to the south and south-west by the mountains of El-búrz. From these and the mountains of Zagros several chains diverge and cross the highland of Armenia, and are continued by Mount Taurus through the peninsula of Asia Minor.

Connected with the Armenian Mountains by a range of hills of small elevation, is the lofty range of mountains, or rather *mountain-terraces*, called the Caucasus, extending between the Black and Caspian Seas. From Mount Taurus, the Mountains of Libanus branch off and run through Syria.

The great system of mountains we have thus traced are continued westward from the shores of the Black Sea, along the southern shores of Europe' to the Atlantic, under the names of the Balkhan, which send off numerous shoots and spurs into Greece; the Alps, from which extend the Apennines through Italy; the Carpathian and Hercynian Mountains which occupy central Europe; and the Pyrenees with their several offshoots into the Spanish peninsula. Other chains seem to be unconnected with this great mountain system, such as the Vindhya and the Ghauts around the Deccan of India, the Ural Mountains, the Scandinavian Alps, and the numerous chains and groups which occupy the islands scattered around the shores of the continents.

In Africa there are continuous mountains of great extent; for example, the Atlas, which extend along the shores of the Mediterranean, the lofty mountains of Abyssinia, the Mountains of the Moon, and the Kong Mountains, which run parallel to the Gulf of Guinea. Other chains, of which little is known, extend along the eastern and western shores of the southern half of Africa. In some places they attain a considerable elevation, such as the Snowy Mountains, in Cape Colony, the highest of which is 10,250 feet above the level of the sea. The chain of Lupata (*the spine of the world*), on the eastern side, and the ranges which extend through Congo and Angola along the west coast, seem to form the declivities of the table-land which occupies the southern portion of the African continent.

In the New World, the Oregon or Rocky Mountains begin on the shores of the Arctic Ocean, nearly under the 70th parallel, and continue south-eastward in an unbroken line until they are separated from the highlands of Mexico by the plain which extends in an easterly direction from the north end of the Gulf of California to the valley of the Rio del Norte. The great table-land of Mexico or Anahuac supports some ranges of considerable extent, as well as numerous isolated mountains, many of which rise to a great height above the sea level, and occupy the country as far as the Isthmus of Panama. Here two flat and low-lying plains, separated by a ridge of hills, stretch across the isthmus from the shores of the Atlantic to the Pacific Ocean. The more eastern of these plains is elevated only a few yards above the sea, and extends in a south-easterly direction to the mouth of the River Atrato. At this point, the Andes, or Cordilleras de los Andes (Chains of the Andes), commence, consisting first of three, then of two parallel ranges, which enclose high plateaus between them, and, finally, about the 20th parallel of south latitude, form a single chain, which continues southward until it is lost in the numerous rocky isles that sink into the southern ocean off Terra del Fuego.

Besides the mountain systems thus traced, others connected with the principal ranges occur in both parts of the New World. Thus in North America a range extends through the peninsula of California, skirting the coast to about the 60th parallel of north latitude. The central portion of this range is called the Californian Mountains, between which and another chain to the eastward, called the Sierra Nevada, or Snowy Mountains of California, is enclosed the well-watered and fertile valley of the Tulares. Through this valley flows the Sacramento river, whose basin is the gold region of modern times.

Eastward beyond the Snowy Mountains, and to the base of the Rocky Mountains, extends the great American Desert, consisting of a series of vast sandy plains. From the Mexican plateau, a ridge of mountains of moderate elevation, called the Ozarks, stretches eastward towards the bed of the Mississippi. The Apalachian Mountains, which run through the United States, form the eastern boundary of the basin of this mighty river.

In South America, the mountains of Venezuela branch off from the Andes, and run in an easterly direction along the shores of the Caribbean Sea. The mountains of Parime or Guiana, and those ridges which traverse the Brazilian table-land, do not appear to be connected with the great system of the Andes.

In order to obtain a connected view of the loftiest and most extensive range of mountains upon the globe, let us suppose a spectator placed in Australia with his face towards the north. America would then be on his right; Asia, Africa, and Europe on his left. Suppose his range of vision to take in the margin waters of the Pacific and Indian Oceans, a splendid amphitheatre of the loftiest mountains on the globe would then bound his view. Along the western coast of America, a mighty range of mountains rises abruptly from the bosom of the ocean, and extends for nearly nine thousand miles from the Cape Horn to the shores of the Frozen Ocean. It then becomes linked with Asia by the Aleutian Isles, and in an enormous line pursues its course in a south-westerly direction through central and southern Asia. As it approaches Africa it becomes somewhat broken, but still maintains its course in the mountains of Persia and Arabia Petræa. Following this belt westward, we find it continued in a double system; one range enters Africa, forms its northern boundary, and terminates in the regions of the Atlas; the other stretches into Europe, skirts the Mediterranean, and breaks up into the French and Spanish mountains—thus forming the western extremity of that great zone of highlands which girds the old and new continents almost throughout their whole extent.

Though the mountain chains of the globe appear unsystematic when viewed in detail, yet when contemplated upon a grand scale they assume the form of an irregular curve, with its secondary chains and offshoots, surrounding the Pacific on the east, north, and west, and presenting a steep face towards its bed.

### II. *Mountain or Upland Plains, Table-lands or Plateaus.*

The above terms are applied to extensive tracts whose general level is considerably elevated above that of the sea.

In order to associate the idea of the relation between lowlands and highlands, and of the successive gradations in the elevation of the soil, with actual data based on accurate measurement, we subjoin a table, in which the heights of the elevated plains of Europe, Africa, and America are given in ascending scale. With these numbers we may then further compare all that has as yet been made known regarding the mean height of the Asiatic plains, or true lowlands:—

| | Feet. |
|---|---|
| **Plateau** of Auvergne | 1,087 |
| „ Bavaria | 1 663 |
| „ Castile | 2,238 |
| „ Mysore | 2,942 |
| „ Caracas | 3,070 |
| „ Popayan | 5,755 |
| „ the vicinity of the Lake of Trana in Abyssinia | 6,076 |
| „ the Orange River (in South Africa) | 6,395 |
| „ Axum | 7,034 |
| „ Mexico | 9,528 |
| „ the Province De los Pastos | 10,231 |
| „ the vicinity of the Lake of Titicaca | 12,853 |

The portions of the earth which we term plains are nothing more than the broad summits of hills and mountains, whose bases rest on the bottom of the ocean. Every plain is, therefore, when considered according to its submarine relations, an elevated phateau, whose inequalities have been covered over by horizontal deposition of new sedimentary formations, and by the accumulation of alluvium.

Some of these support on their surfaces large mountain ranges, which, although of small height above the plateau that forms their base, are yet of great elevation above the level of the sea. The exterior boundaries of table-lands generally consist of mountain chains, which in some cases descend suddenly and abruptly into the surrounding plains. In others they gradually diminish in elevation, forming a succession of mountain terraces at different levels until they are lost in the adjacent lowlands. In either of these cases the mountains, when seen from the plateaus upon which they rest, appear less than their real height above the sea. A correct idea of their altitude can only be obtained by viewing them from the lowlands on the opposite side of the chain.

*Asiatic Table-lands.*—No continent exhibits plateaus so elevated, so numerous, so extensive, as Asia and Africa. Instead of one or two chains of mountains, like the Andes, central Asia is traversed by four immense chains, which support vast table-lands of from 5,000 to 14,000 feet in elevation, and the loftiest mountains of the globe. The extent of this elevated region is more than 2,400 miles long by 1,500 miles broad. The principal mass of Western Asia is nothing but a plateau, from 3,000 feet to 6,000 feet in height. It has been calculated that the mountains and plateaus of Asia cover five-sevenths of its surface, while the plains occupy only two-sevenths. The most widely-extended highland is that which occupies the central parts of Asia, comprehending a large portion of Chinese Tartary, or Mongolia, and the whole of Tibet. The area of this central table-land has been computed at about 3 million square miles; its elevation is not uniform: in the southern and south-western parts the plains of Tibet attain the height of 12,000 feet above the sea-level, whilst the northern and eastern portions do not rise on an average above 3,000 or 4,000 feet. The central portion is occupied by the great Desert of Gobi.

This vast plateau, with the chains which surround and diverge from it, constitutes the great framework of Asia. Long chains, extending from the north to the south, in the direction of the meridians, the Beloor-tágh and Solimaun range, cut at right angles the great east-west axis. The Beloor-tágh forms the western margin of the high central plateau; the Solimann, the eastern margin of the table-land of Iran: the one on the north, the other on the south; so that these two solid masses touch each other at their opposite angles, south-west and north-east. The remarkable point where these high ranges intersect, and the table-land and the plains, spread out at their feet, touch each other, is the Hindoo-Koosh. These features of relief sever the continent into two parts of almost equal extent, but of very unequal importance; Eastern Asia on the one side, and Western Asia and Europe on the other,—the Mongolian races and the White races.

This separation is so deeply marked in nature and in the nations that even the ancients, with the practical sense belonging to them, made a division of Asia *intra* Imaum, and Asia *extra* Imaum; that is, Asia this side and Asia beyond the Beloor-tagh and the Hindoo-Koosh, as they also divided the north and the south into Scythia-Nomadic Asia and Asia Proper, or civilized Asia.

Eastern Asia forms, in fact, a continent by itself alone. A vast pile of highlands, a plateau in the form of a trapezium, occupies the entire centre, and forms the principal mass. It seems to invade everything: it is the prominent feature, and gives a distinctive physiognomy to the continent. It is surrounded on all sides by lofty ranges capped with snow, which seem, like towering ramparts, to guard it from attack and to isolate it on every side. On the south the Himalaya, on the west the Beloor-tágh, on the north the Altai, on the east the Khing-shan and the Yung'ling, form an enclosure almost unbroken, the detached summits of which belong to the loftiest mountains of the earth. A small number of natural entrances lead to the interior, or give an exit from it. The only gate which offers some facility is Zungary, between the Thian-Shan and the Altai; everywhere else, high and frozen passes bound the view.

The interior of this vast enclosure is cut by numerous chains, the highest of which, those of the Kuenlun on the south, and of the Thian-Shan on the north, are parallel to the Himalaya and the Altai, and divide the soil into several basins or high bottoms. In all this extent there is no fertile and easily-cultivated plain; everywhere stretch the steppes, a dry and cold desert, or seas of drifting sand. Nevertheless, a considerable depression in Eastern Turkestan, where the Tarim flows, and whose bottom is marked by Lake Lop, allows the cultivation of the vine and the cotton-tree at the foot of the Thian-Shan; but this is an exception. Apart from some privileged localities, nature here does not permit a regular tillage, and dooms the tribes of these regions to the life of shepherds and herdsmen—the nomadic life.

To the south of this highland, and connected with it by the mountain knot of the Hindoo-Koosh, is another plateau, termed the Western Highland of Asia, comprising Persia and Afghanistán, and having a superficial area of about 850,000 square miles. The eastern portion of this (Afghanistán) is in some parts elevated as much as 7,000 feet. Towards the west it slopes gradually, until, in Persia, its elevation is not more than 3,000 or 4,000 feet. Proceeding towards the north-west, between the southern extremities of the Black and Caspian Seas, we find the small and mountainous highland of Armenia, at an elevation in some parts of 7,000 feet.

Further westward, the plateau of Anatolia, in Asia Minor, is for the most part above 2,000 feet in elevation. Entirely unconnected with the more central table-lands in the interior of the continent are the highlands of the Deccan, or Dukhán, and Arabia. The former constitutes a plateau of between 2,000 and 3,000 feet in height, and is separated from the Asiatic central table-land by the basin of the Ganges. The western part of the peninsula of Arabia rises in some places to the height of 3,000 and 4,000 feet.

*African Table-lands.*—The portion of Africa which lies to the north of the 16th parallel, comprehending the Sahara, or Great Desert, constitutes a plateau of small elevation. The part of this containing the kingdom of Fezzan is considerably depressed below the level of the sea. The whole of the interior of Africa, south of the Sahara, from the 5th parallel of north latitude to Cape Colony, seems to be only an enormous pile of table-lands, probably in some places of great elevation. The high regions form two-thirds of the continent.

*European Table-lands.*—The highlands of Europe, though of small extent when compared with the immense tracts of Asia and Africa, are, nevertheless, equally marked in character.

The Spanish peninsula consists chiefly of an elevated plateau, which reaches on its north side to a height of 3,000 feet, and on its south to about 2,000 feet. A portion of this highland, called the Plains of Old Castile, is as bare and treeless as the Siberian Steppes. The plateau of Bavaria reaches a height of 2,000 feet, and the south-west portion of the Scandinavian peninsula constitutes a platean of moderate elevation. On the great European lowland there are several small plateaus, such as the plateau of the Baltic, between the Vistula and the Elbe, the plateau of the Valdai, the plateau of Old Bulgaria, the plateau of Finland, &c.

*North-American Table-lands.*—The highlands of the New World, though of great elevation, are not so extensive as those in the eastern continent. They form only a narrow band, jammed upon the western coast of the two continents. The northern and north-eastern parts of North America are occupied by highlands of small elevation: along the base of the Rocky Mountains a succession of barren plains extends eastward, for a distance of 400 miles, towards the valley of the Mississippi. In central America, the enormous tableland of Mexico or Anahuac commences about the 42nd parallel, and extends southward to the peninsula of Tehuantepec. This vast highland consists of a series of plains of different elevations. The highest part of the plain of Toluca, upon which the city of Mexico stands, is 9,000 feet above the level of the sea; further to the south-east are the plateaus of Guatimala and Honduras, which exceed 6,000 feet.

*South-American Table-lands.*—Between the lofty regions of the Andes are situated table-lands which almost equal those of Asia in elevation. The plateau of Quito, under the equator, is about 9,000 feet, and that of Pasco, between the 10th and 12th parallel of south latitude, 11,000 feet in elevation. The table-land of Potosi or Titicaca, which contains the great lake of that name, is 12,700 feet above the sea: around this plain are clustered the loftiest summits of the Andes.

The direction of the principal reliefs, the prolongation of the Old World from east to west, and its more northern position, cause it to belong rather to the temperate zones than to the zone of the tropics, and give, throughout its whole length, a more similar climate.

If America is distinguished by the simplicity of its interior structure, and by the unity of character that is the consequence, the Old World, on the contrary, presents the variety of structure carried to its utmost limits. While America is constructed upon one and the same plan in the two continents, the Old World has at least three separate masses, namely, Asia-Europe, Africa, and Australia; for, notwithstanding their resemblance in certain general features, each of these three continents has none the less its special structure, which is not the same in Australia as in Africa, nor in Africa as in Asia-Europe. The great mass of Asia-Europe, which may be well called a single continent, is of a triangular form, the western point of which is Europe. Like the New World, it is divided into two parts by a long ridge of heights, of mountain chains, and of table-lands, forming a line of the highest elevations, and the axis of this continent; the Himalaya, the Hindoo-Koosh, the Caucasus, the Alps, the Pyrenees, are analogous to the long American Cordilleras. This ridge also divides the Old World into two unequal parts, but it is not placed on one of the edges of the continents, as in America. It is only a little out of the centre, so that it divides the whole surface into two opposite slopes, unequal, doubtless, but of which the narrowest is nevertheless considerable. The northern slope is more vast; it contains all the great plains of the north, but is less favoured by the climate and by the forms of the soil. The southern slope is less extended, but it enjoys the most beautiful climate; nature is most bountiful there; it is more indented, more variously moulded; it possesses all those fine peninsulas, the two Indies, Arabia, Asia Minor, Greece, Italy, Spain, which form the wealth of Asia and Europe.

In America the plains are always situated on the same side of the chain of the Andes, but in Asia-Europe the table-lands and the plains are situated on the two sides of the continental axis alternately. Thus, in Eastern Asia, the great plateau of Tibet and Mongolia is on the north, and the plains of the Ganges are on the south. In Western Asia, on the contrary, the plateaus of Afghanistán and Persia are on the south, the plains of Tartary on the north. In Europe, on the south of the Alps and the Pyrenees, are the peninsulas and their gulfs, the mountain chains and their plateaus; in general, countries more elevated, but broken and dispersed; on the north, less lofty chains, but more varied, countries more continuous and less cut up, as the great plains of the north of Germany. The axis of Asia-Europe, instead of forming a continuous wall, without cleft and without breaks, like the Andes, is composed of several isolated systems, independent of each other, often leaving wide openings between them. Sometimes it is a sea that separates them; sometimes vast plains serve as high roads to the invading nations, who pass from one side to the other of this great barrier, from the northern to the southern world. Thus the lofty chains of the Himalaya and of Hindoo-Koosh sink towards the west and disappear, and no important ridge any longer separates the inhabitants of the steppes of Lake Aral from the dweller on the table-land of Iran. The Caucasus rises abruptly from the level of the Caspian, and terminates in the same way at the margin of the Black Sea; and it is only upon the high shore of this sea that the mountains of Transylvania and the Balkhan again begin to separate the northern from the southern world. This break opens to the polar winds and the northern tribes the broad gate which has cost the south such fierce assaults. The Alps, finally, do not touch the Pyrenees, and the Languedoc Canal, uniting the Mediterranean with the ocean, proves the importance of this communication between the two basins.

In the Old World, variety of structure is carried to the extreme. Thus a large number of chains, parallel to the great axis, and of others cutting it transversely, like the Bolor, the Ghauts of the Deccan, and the numerous chains of Indo-China, the Libanus, the Oural, the Scandinavian Alps, cut the soil in all directions, and divide it into a multitude of different basins, of natural regions, which have their several limits, their climate, and their special character. Thus, while America is distinguished by simplicity of forms and unity of plan, the Old World has in turn a diversity of reliefs, of combinations of mountain chains, of plateaus, and of plains, multiplying to infinity those differences, those interior contrasts, with which America is less richly provided, and which is one of the most powerful means of development.

## III. *Use of Mountains in the Economy of Nature.*

Mountains are among the grandest and most sublime features of the globe. Their gigantic proportions, their lofty projections, and their broken and varied forms, present to the eye a magnificent spectacle, impressing the mind with ideas of power, majesty, and beauty, while the many important offices they perform in the economy of nature wonderfully display the wisdom of God, and his goodness towards man.

Their summits, rising into the higher regions of the atmosphere, arrest the clouds, whose waters they gather into their internal and exhaustless reservoirs. "These mighty tanks, embowelled in mountain regions, diffuse their waters by a thousand secret channels under the surface of the soil, cherish the deep roots of trees, and feed the thirsty herbage, or gush out in the green places of the earth in springs and fountains." These, again, unite their waters, and form brooks, which expand themselves into rivers that become the highways of extensive commerce. Were there no mountains, there would be neither springs, fountains, brooks, rivers, nor lakes. The moisture raised by the process of evaporation from the earth, would, when returned to it, be absorbed by arid and thirsty soils: or, saturating the surface, would produce swamps and morasses. Mountains, by raising the land and rendering it sloping, increase the surface of the earth, and, consequently, its productions. The elevated table-lands of the torrid zone greatly augment the amount of habitable land. The snow-clad summits of mountains replenish the sources of springs and rivers. The *detritus* washed from their sterile shoulders when transported by rivers to lower and warmer situations, exercises a fertilizing energy, and yields a luxuriant vegetation.

Upon their sides grow a variety of herbs, plants, and forest trees, which give diversity and richness to the scenery, and thus destroy the dreary monotony that would otherwise exist. They, moreover, afford sustenance and shelter to many animals, which in their turn minister to the wants and comfort of man.

Mountains protect from cold and piercing winds, and foster in their bosoms the more delicate families of plants. In many countries they constitute a formidable barrier to the ocean, breaking the rage and fury of its storms. Several chains, by the upheaval of the lower strata of the earth, have placed vast magazines of mineral wealth within the reach of man, and have thereby created employment for thousands of inhabitants, and supplied the sinews of commerce.

Their elevation, position on the surface of the globe, proximity to, or remoteness from, the sea, the winds they obstruct or give passage to, the aspect they present to the sun's course, cause them to exert an immense and important local influence upon climate; they have, moreover, a climate of their own.

Upon their direction and elevation depend not only the course and magnitude of river systems, but the distribution of the *Flora* and *Fauna* of subjacent countries, and the character and social condition of the inhabitants. They have ever influenced the spread of languages, defined the boundaries of nations, modified wars and conquests, and checked or facilitated the march of civilization.

Finally, mountains are the strongholds of national freedom, the cradles of liberty and independence, the guardians of moral virtue, and the inspirers of pure and sincere devotion. Nowhere can we find these grand and striking objects of Nature more beautifully alluded to than in the Book of Job and in the Psalms. The language of David, that great student and lover of Nature, abounds with the most splendid imagery drawn from these stupendous works of God.

### IV. *Lowland Plains.*

Plains are distinguished from mountainous districts by being only slightly elevated above the sea-level; in some places, indeed, they are considerably below it, as is the case with the depressed region round the Caspian and Sea of Aral, and with the Jordan Valley. The plains of the Old Continent are exceedingly varied in their surface; some are gently waving, others prominently undulating; some, again, are studded with hills, traversed by valleys, or intersected by ravines. In the American Continent the plains present a more perfectly level and horizontal surface.

If we call the Old World the world of plateaus, it is not because great plains are wanting there; each of the continents contains an extensive plain, more or less diversified by low hills: the land lying beyond the 50th parallel presents broad extensive flats towards the Polar Ocean. In Africa, the tract between the 10th and 30th parallels is almost a dead level. The traveller may cross the Ancient World, from the Atlantic to the Pacific Ocean, for a distance of more than 6,000 miles, without encountering an eminence of more than a few hundred feet in height. But the situation of these plains of the Old World, under the frozen sky of the north, and under the fires of the tropics, together with the nature of their soil, takes from them all their importance. The one is a frozen waste—

a Siberia; the other a burning desert; and neither the one nor the other is called to play an essential part, nor do they impress upon their respective continents their essential character. The central regions of North and South America consist of immense plains, which form the basins of the mightiest river arteries on the surface of the globe.

*European Plains.*—More than two-thirds of the surface of Europe is occupied by an immense plain, which extends from the shores of the German Ocean, comprehending the lowlands of Northern France, Holland, North Germany, the greater part of Prussia, and the whole of European Russia to the base of the Ural Mountains. On this great level there scarcely occurs an elevation deserving the name of a hill, so that a line drawn from London to the city of Kazan, on the banks of the Volga, would indicate an almost perfect level. Beyond the Ural Mountains this lowland is continued eastward in the great Siberian plain to the mountain ranges that border on the Pacific. On the European level there are several lowland plains, such as the lowlands of Azof (the commencement of the "Steppes"), the lowland of Poland; the bog-land of Rokitno, in central Russia; the woody plains of Lithuania, the boggy tracts of Sawolotchie, and the tract of the Tundra, in Northern Russia. In Lapland extends the lowland of Laponia; and southward, extensive lowlands surround the Gulf of Bothnia.

Omitting the great Russian plain, Europe is a mountainous continent. Traverse it from one end to the other, whether in its central mass or in its peninsulas, and its soil will everywhere be found to be modified, cut in all directions by chains of mountains which intersect each other. In all this part of the continent, the largest existing plain, that of Northern Germany and Poland, is only 600 miles long by 200 broad; it is the extremity of the great Asiatic plains in the north. The other plains, as those of France, of Hungary, of Lombardy, are smaller in extent, and do not deprive this part of the continent of the mountainous character which is essential to it.

*The Heaths and Landes of North-west Germany* extend from Lower Silesia to the kingdom of Hanover, and to the extremity of Jutland. To the east of the Elbe there are extensive tracts of sand, containing a few hills, and studded with numerous lakes. Along the shores of the Baltic there are a few oak forests. The district between the Elbe and the Weser is exceedingly sterile, being covered with heath, marshes, and some pine-woods. To the west of the river Ems there are lands covered with swamps and stagnant pools; and in the Lower Rhine province the lands are coated with heath.

In Southern Europe an extensive sandy plain, occupied by heaths and marshes, stretches between the Gironde and the Pyrenees. In the department of Landes, on the right bank of the Adour, there is a sterile plain, abounding in pools, marshes, and heath. Around the mouth of the Rhone there is an extensive plain of shingle.

The rich and highly-cultivated plains of Lombardy have ever been considered as the most productive in the world. In the kingdom of Naples there are landes of considerable extent.

*The Plain of Hungary*, which forms the northern basin of the Theiss and Danube, is of considerable extent, and abounds in barren and marshy tracts, termed *Puszta*. The Wallachian or Bulgarian lowland spreads around the lower course of the Danube.

The plains in the British Islands we shall mention further on.

Around the central mass of Asia, towards the four cardinal points, extend broad and low plains, watered by the rivers pouring down from its heights, which rank among the largest in the world. On the north is the most extensive but the least important, the frozen and barren plain of Siberia, with the streams of the Obi, the Yenesei, the Lena; on the east, the low country of China, where meet and unite the two giant rivers of the Old World, those two twin rivers, which, born in the same cradle, flow on to die in the same ocean; on the south, the plain of Hindostan, moistened by the fresh and abundant waters of the Himalaya, and the sacred streams of the Indus and the Ganges; on the west, finally, the plain of Turan, with the two rivers Gihon and Sihon, and its salt seas, to which Western Asia already lays claim. It is in these plains, with fruitful alluvial soil, and on the banks of these ancient rivers, that were developed the earliest, almost the only, civilized nations belonging to this continent. But the warm and maritime region of the east and the south, connected with the rich peninsulas of India, is by far the most favoured of all. China and India, therefore, have given birth to the two great cultivated nations of Eastern Asia.

*Asiatic Plains.*—The great and densely-populated plain of Northern China lies between the mountain ranges on the east side of the great highland and the Pacific Ocean. The lowland of Hindoostan occupies the north part of India, between the plateau of the Deccan and the Himalaya Mountains. The tributaries of the Indus flow through an extensive plain, called the Punjaub. The lower portion of the Indus flows through the plain of Sinde. The most extensive level in Asia is

*The Great Siberian Plain.*—This immense expanse is bounded on the south by the central highland of Asia, from which it stretches to the shores of the Arctic Ocean; here it gradually sinks into the Tundra, or waste of sloughs and marshes that prevail on the Asiatic continent beyond the 70th parallel.

The most remarkable portions of that great level are

*The Steppes.*—This Russian term, signifying *desert*, is applied to the extensive lowland levels which lie to the south-east of Europe, and that part of north-west Asia known as Turkestan or Independent Tartary, and which is inhabited by the nomade hordes of the Kirghiz Cossacks. As the surface of this vast district of country is exceedingly varied in its character, we shall briefly consider each of the great Steppes separately.

*The Steppe of South European Russia* extends on each side of the lower course of the Volga, having for its boundaries the Don, Sea of Azof, and the Chain of the Caucasus on the west and south, and the Caspian and the River Ural on the south-east and east. This Steppe is characterized by low hills of loose shelly sand, between which are rich pasture lands. The plain abounds in marshy hollows, salt streams, and brine pools. The vegetation of the hollows consists chiefly of reeds, willows, poplars, and the wild olive. There are also barren patches covered with tufts of saline plants.

*The Steppe of the Kirghiz*, stretching to the east of the River Ural and around the Sea of Aral, occupies nearly the whole of the country of Turkestan, and is similar in character to that just described. To the north of this is

*The Steppe of Ischim*, which reaches from the slopes of the Ural Mountains to the River Irtish. The north-east part of this Steppe is clothed with dense forests, abounding in game and numerous fur-bearing animals. Beyond the Irtish commences

*The Steppe of Barabinsk*, which lies between the Irtish and the Upper Obi. This district along the watercourses abounds in pasture lands of luxuriant grass; in the north and north-west there are extensive forests, but the south is less fertile and almost destitute of trees. The country around the great lake Tschany (lat. 54° 30′ N., long. 78° E.) is exceedingly rich, and abounds in aquatic game, with great numbers of elks, roebucks, and wild boars.

Different hordes of Kirghiz inhabit these Steppes; they lead an easy and wandering life, and are continually shifting their ground to procure new pasturage for their numerous cattle, consisting of horses, camels, horned cattle, sheep, and goats, which form the sole wealth of these independent herdsmen.

Further northward, the Siberian plains are intersected by the great rivers Obi, Yenesei, and Lena. Around the lower courses of these rivers extend immense frozen marshes, whose surface is covered with moss; and sometimes these wastes are interspersed with sand-hills, crowned with clumps of stunted birch and other dwarf shrubs.

*African Plains.*—Central Africa, or that part of the interior of Africa which extends northward from the supposed Mountains of the Moon (Jebel el-Kumri) to the Sahara, may be regarded as a lowland. This tract contains the basin of Lake Chad, and a great part of that of the River Quorra, or Niger. It constitutes the middle and larger portion of Soudan or Negroland, under which name is comprehended the entire region from the Atlantic Ocean to the highlands of Abyssinia, and from the southern borders of the desert to the Gulf of Guinea and the Mountains of the Moon.

*American Plains.—The Savannahs or Prairies.*—The central portion of North America, from the Gulf of Mexico to the Frozen Ocean, is one continuous plain. This immense extent of country, estimated by Humboldt at 2,430,000 square miles, possesses almost every variety of climate and vegetation. A low water-shed divides it into a northern and southern basin, the former sending off its waters into the great chain of the Canadian Lakes, Hudson's Bay, and the Polar Ocean; the latter is drained by the Missouri and the Mississippi, whose waters are poured into the Gulf of Mexico. It is this southern basin, watered by these mighty rivers and their affluents, that contains the extensive grass-covered tracts, called Savannahs or Prairies. Along the Illinois River, and also in other of the eastern parts of the basin of the Mississippi, there are prairies of 1,200,000 acres in extent. But it is on the western side of the Mississippi that these immense meadows chiefly lie.

The territory between this river and the mountains is not, however, a continued savannah; woods are met with in some places, and elsewhere swamps and pools abound; whilst along the base of the Rocky Mountains a vast sandy desert extends for about 400 miles. For a considerable distance on each side of the Mississippi, and on the higher grounds near the Alleghany and Rocky Mountains, there are dry, grassy, and almost treeless wastes, or barren grounds, somewhat resembling the woodless prairies.

The Mississippi, in its lower course, is fringed on each side by extensive forests of pine. Around the mouth of the river, and along the south-east coast for several miles, there are extensive morasses and sandy tracts destitute of trees: these dreary and uninteresting flats are called *Pine Barrens.*

The waters which flow through this great southern basin teem with alligators and tortoises. The surface of these streams is covered with millions of migratory water-fowl, which perform their annual voyage between the shores of the Gulf of Mexico and the Canadian Lakes.

The Savannahs or Prairies may be arranged into three kinds:—

1. The Heathy or Bushy Prairies, which contain springs, and are covered with grass, shrubs, grape-vines, and varieties of flowers. These occupy a large portion of the country to the south of Lake Michigan, in the States of Indiana and Illinois; and in the State of Missouri, through which the river of that name in its lower course flows before it joins the Mississippi.

2. The Dry or Rolling Prairies, so called because they are without swamps or pools, and on account of their wavy surface. They have no vegetation but grass, weeds, and flowers. These prairies are the most common and extensive; they spread about the upper courses of the western feeders of the Missouri and Mississippi, stretching nearly to the base of the Rocky Mountains. Over these prairies bisons roam in herds of from 40,000 to 50,000. In this region also stags, or wapitis, and deer are numerous, and antelopes abound in herds of several hundreds along the borders of the Missouri, above the Platte River. Between the Arkansas and Red Rivers there are droves of wild horses, and in summer vast numbers of wild goats feed along the banks of the Mississippi. The territory around the upper course of the Missouri is inhabited by grizzly bears, badgers, beavers, otters, foxes, wolves, racoons, opossums, squirrels, porcupines, skunks, and the jaguar or American tiger.

3. The Moist or Wet Prairies, the smallest division, abound in pools without issue, left by the floods of the rainy

seasons. They are covered with a rich vegetation of tall rank grass.

*The Llanos.*—The whole of the interior of South America, from the coast chain of Venezuela in the north to the Strait of Magalhaens on the south, upwards of 4,500 miles, consists of an immense continuous lowland, whose mean height is little above the sea level. This extensive tract is divided by ridges of low hills into three great river basins—that of the Orinoco on the north, that of the Amazon in the centre, and that of the La Plata on the south. The flat regions on each side of these mighty streams are distinguished as Llanos, Selvas, and Pampas. *The Llanos*, or *Level Fields*, is the name given to those vast plains in Venezuela and New Grenada, which occupy a surface of 260,000 square miles, between the Orinoco on the east, and the chain of the Andes on the west. The chief characteristic of these plains is a perfectly level surface, the mean height of which does not exceed 200 feet. So gently do they slope towards the sea, that a slight rise in the Orinoco, or sometimes even the wind, reverses the current of the tributary streams.

Notwithstanding this uniformity of surface, two kinds of inequalities exist; the first, called *Brancos*, are layers of sandstone or limestone, standing 4 or 5 feet higher than the plain, and are frequently several miles in extent. The second, called *Mesa*, are composed of vaulted elevations, which rise to the height of a few feet.

The vegetation of the Llanos consists chiefly of rich grass, varying from a few inches to 4 feet in height. The only trees that are met with are a few clumps of different varieties of palms: around these clumps the soil is most fertile.

The aspect of the Llanos changes with the seasons. In the rainy seasons the whole of the country for hundreds of square miles is inundated, but when the waters subside the plains are covered with the most luxuriant verdure, the grass along the watercourses rising to the height of several feet. Here the jaguar, or tiger of the American continent, lurks to spring upon some straggler from the droves of mules and horses that feed upon the plains. In the dry season the Llanos assume the aspect of a desert; the intense heat burns up the grass, the earth cracks, and huge alligators and serpents remain buried in the dried mud, till they are awakened from their long sleep by the first showers of spring. The rivers and pools abound with the gymnoti, or electrical eels, and over the plains roam large herds of native deer. The great wealth of the Llanos consists of the vast herds of oxen which feed upon them. In 1548, Christoval Rodriguez first let loose horned cattle on these extensive plains, and since that time they have increased to almost countless numbers.

Humboldt has so graphically described these plains in his "Tableaux de la Nature," that we are tempted to give the following passage:—

"Since the discovery of the new continent, its plains (Llanos) have become habitable to man. Here and there towns have sprung up on the shores of the Steppe-rivers, built to facilitate the intercourse between the coasts and Guiana (the Orinoco district). Everywhere throughout these vast districts the inhabitants have begun to rear cattle. At distances of a day's journey from each other we see detached huts woven together with reeds and thongs, and covered with ox-hides. Innumerable herds of oxen, horses, and mules (estimated at the peaceful period of my travels at a million and a half), roam over the Steppe in a state of wildness. The prodigious increase of these animals of the Old World is the more remarkable from the numerous perils with which, in these regions, they have to contend.

"When, beneath the vertical rays of the bright and cloudless sun of the tropics, the parched sward crumbles into dust, then the indurated soil cracks and bursts as if rent asunder by some mighty earthquake; and if, at such a time, two opposite currents of air, by conflict moving in rapid gyrations, come in contact with the earth, a singular spectacle presents itself. Like funnel-shaped clouds, their apexes touching the earth, the sands rise in vapoury form through the rarefied air in the electrically-charged centre of the whirling current, sweeping on like the rushing water-spout which strikes such terror into the heart of the mariner. A dim and sallow light gleams from the lowering sky over the dreary plain. The horizon suddenly contracts, and the heart of the traveller sinks with dismay as the wide Steppe seems to close upon him on all sides. The hot and dusty earth forms a cloudy veil, which shrouds the heavens from view, and increases the stifling oppression of the atmosphere; while the east wind, when it blows over the long-heated soil, instead of cooling adds to the burning glow.

"Gradually, too, the pools of water, which had been protected from evaporization by the now seared foliage of the fan-palm, disappear. As in the icy north animals become torpid from cold, so here the crocodile and the boa constrictor lie wrapt in unbroken sleep, deeply buried in the dried soil. Everywhere the drought announces death, yet everywhere the thirsting wanderer is deluded by the phantom of a moving, undulating, watery surface, created by the deceptive play of the reflected rays of light (the mirage). A narrow stratum separates the ground from the distant palm-trees, which seem to hover aloft, owing to the contact of currents of air having different degrees of heat, and therefore of density. Shrouded in dark clouds of dust, and tortured by hunger and burning thirst, oxen and horses scour the plain, the one bellowing dismally, the other, with out-stretched necks, snuffing the wind, in the endeavour to detect, by the moisture in the air, the vicinity of some pool of water not yet wholly evaporated. The mule, more cautious and cunning, adopts another method of allaying his thirst. There is a globular and articulated plant, the Melocactus, which encloses under its prickly integument an aqueous pulp. After carefully striking away the prickles with his fore-feet, the mule cautiously ventures to apply his lips to imbibe the cooling thistle juice. But the draught from this living vegetable spring is not always unattended by danger, and these animals are often observed to have been lamed by the puncture of the cactus thorn.

"Even if the burning heat of day be succeeded by the cool freshness of night, here always of equal length, the wearied ox and horse enjoy no repose,—huge bats now attack the animals during sleep, and vampire-like suck their blood; or, fastening on their backs, raise festering wounds, in which mosquitoes, hippobosces, and a host of other stinging insects, burrow and nestle. Such is the miserable existence of these poor animals when the heat of the sun has absorbed the waters from the surface of the earth.

"When, after a long drought, the genial season of rain arrives, the scene suddenly changes: the deep azure of the hitherto cloudless sky assumes a lighter hue. Scarcely can the dark space in the constellation of the Southern Cross be distinguished at night. The mild phosphorescence of the Magellanic clouds fades away. Even the vertical stars of the constellations Aquila and Ophiuchus shine with a flickering and less planetary light. Like some distant mountain a single cloud is seen rising perpendicularly on the southern horizon: misty vapours collect and gradually overspread the heavens, whilst distant thunder proclaims the approach of the vivifying rain.

"Scarcely is the surface of the earth moistened before the teeming Steppe becomes covered with kyllingiæ, with the many-panicled paspalum, and a variety of grasses. Excited by the power of light, the herbaceous mimosa unfolds its dormant, drooping leaves, hailing, as it were, the rising sun in chorus with the matin song of the birds and the opening flowers of aquatics. Horses and oxen, buoyant with life and enjoyment, roam over the plains. The luxuriant grass hides the beautifully-spotted jaguar, who, lurking in safe concealment, and carefully measuring the extent of the leap, darts, like the Asiatic tiger, with a cat-like bound on his passing prey.

"At times, according to the account of the natives, the humid clay on the banks of the morasses is seen to rise slowly in broad flakes. Accompanied by a violent noise, as on the eruption of a mud volcano, the upheaved earth is hurled up high into the air. Those who are familiar with the phenomenon fly from it; for a colossal water-snake or a mailed and scaly crocodile, awakened from its trance by the first fall of rain, is about to burst from its tomb.

"When the rivers bounding the plain to the south, as the Arauca, the Apure, and the Payara, gradually overflow their banks, nature compels these creatures to live as amphibious animals, which, during the first half of the year, were perishing with thirst on the waterless and dusty plain. A part of the Steppe now presents the appearance of a vast inland sea. The mares retreat with their foals to the highest banks, which project, like islands, above the spreading waters. Day by day the dry surface diminishes in extent. The cattle, crowded together, and deprived of pasturage, swim for hours about the inundated plain, seeking a scanty nourishment from the flowering panicles of the grasses which rise above the lurid and bubbling waters. Many foals are drowned, many are seized by crocodiles, crushed by their serrated teeth, and devoured. Horses and oxen may not unfrequently be seen which have escaped from the fury of this bloodthirsty and gigantic lizard, bearing on their legs the marks of its pointed teeth.

"This spectacle involuntarily reminds the contemplative observer of the adaptability granted by an all-provident nature to certain animals and plants. Like the farinaceous fruits of Ceres, the ox and horse have followed man over the whole surface of the earth,—from the Ganges to the Rio de la Plata, and from the sea-coast of Africa to the mountainous plain of Antisana, which lies higher than the Peak of Teneriffe.

In the one region the northern birch, in the other the date-palm, protects the wearied ox from the noonday sun. The same species of animal which contends in eastern Europe with bears and wolves is exposed in a different latitude to the attacks of tigers and crocodiles.

"The crocodile and the jaguar are not, however, the only enemies that threaten the South-American horse; for even among the fishes it has a dangerous foe. The marshy waters of Bera and Rastro are filled with innumerable electric eels, who can at pleasure discharge from every part of their slimy, yellow-specked bodies a deadening shock. This species of gymnotus is about five or six feet in length. It is powerful enough to kill the largest animals when it discharges its nervous organs at one shock in a favourable direction. It was once found necessary to change the line of road from Uritucu across the Steppe, owing to the number of horses, which, in fording a certain rivulet, annually fell a sacrifice to these gymnoti, which had accumulated there in great numbers. All other species of fish shun the vicinity of these formidable creatures. Even the angler, when fishing from the high bank, is in dread lest an electric shock should be conveyed to him along the moistened line. Thus, in these regions, the electric fire breaks forth from the lowest depths of the waters.

"The mode of capturing the gymnotus affords a picturesque spectacle. A number of mules and horses are driven into a swamp, which is closely surrounded by Indians, until the unusual noise excites the daring fish to venture an attack. Serpent-like they are seen swimming along the surface of the water, striving cunningly to glide under the bellies of the horses. By the force of their invisible blows numbers of the poor animals are suddenly prostrated; others, snorting and panting, their manes erect, their eyes wildly flashing with terror, rush madly from the raging storm; but the Indians, armed with long bamboo staves, drive them back into the midst of the pool.

"By degrees, the fury of this unequal contest begins to slacken. Like clouds that have discharged their electricity, the wearied eels disperse. They require long rest and nourishing food to repair the galvanic force which they have so lavishly expended. Their shocks gradually become weaker and weaker. Terrified by the noise of the trampling horses, they timidly approach the banks of the morass, where they are wounded by harpoons, and drawn on shore by non-conducting pieces of dry wood.

"Such is the remarkable contest between horses and fish. That which constitutes the invisible but living weapon of these inhabitants of the waters—that which, awakened by the contact of moist and dissimilar particles, circulates through all the organs of animals and plants—that which, flashing amid the roar of thunder, illuminates the wide canopy of heaven—which binds iron to iron, and directs the silent recurring course of the magnetic needle—all, like the varied hues of the refracted rays of light, flow from one common source, and all blend together into one eternal all-pervading power."

*The Selvas*, or *Forest Plains of the Amazons*, stretching between the Andes and the Atlantic, comprise the most extensive and continuous plain in the world.

This vast region is densely covered with primeval forests, interspersed with open patches of grass and marsh lands, similar in character to the Llanos and Prairies. The woods are composed of large trees of various sizes and heights, and differing greatly in species: on a space of twenty square yards they may be found thirty or forty trees, all of different species. The intervals between the trees are filled up with grass, shrubs, and bushes of various kinds and sizes, the whole being closely interlaced and matted together by numerous climbing plants and creepers, thus forming a woody fabric quite impenetrable to the foot of man. In this mass of tangle and underwood a few small openings appear, through which the jaguar and other wild beasts find access to the beds of the rivers. These immense forests are populated by monkeys in incredible numbers, and of various species, which are hunted by the natives, who dry and eat their flesh. Birds of various kinds and of every variety of plumage are seen along the banks of the rivers. This is the grand region of serpents, some of which are venomous.

This region deserves, in the strictest sense of the word, to be called a primeval forest, a term that has, in recent times, been so frequently misapplied. Primeval, or primitive, as applied to a forest, a nation, or a period of time, is a word of rather indefinite signification, and generally but of relative import. If every wild forest, densely covered with trees, on which man has never laid his destroying hands, is to be regarded as a primitive forest, then the phenomenon is common to many parts both of the temperate and the frigid zones; if, however, this character consists in impenetrability, through which it is impossible to clear with the axe, between trees measuring from eight to twelve feet in diameter, a path of any length, primitive forests belong exclusively to tropical regions. This impenetrability is by no means, as it is often erroneously supposed in Europe, always occasioned by the interlaced climbing "lianes," or creeping plants, for these often constitute but a very small portion of the underwood. The chief obstacles are the shrub-like plants which fill up every space between the trees, in a zone within which all vegetable forms have a tendency to become arborescent.

*The Pampas*, an Indian term signifying *flats*, comprise the third great level region in the central and southern parts of South America. They consist for the most part of treeless plains, which extend from the sandy plateau of Campos Parexis, in 15° S. lat., for 2,000 miles to the most southern limits of the continent; and from the Andes to the river Parana, and the Atlantic Ocean. The northern part of this immense plain varies in width from 280 to 460 miles. In the central portion (about 35° S. lat.) its breadth is nearly 900 miles; towards the south it contracts to about 240 miles. Its area has been roughly estimated at about 840,000 square miles, or nearly four times the extent of France. The surface of the northern district presents an alternation of woods, swamps, salt lakes, bushes, and grass fields. Proceeding towards the south, the woods gradually disappear, and the swamps are succeeded by drier ground.

To the south of lat. 28° the surface is almost a dead level, covered with tall coarse grass, lucern, thistles, and gaudy flowers. As we approach the southern portion of this great plain about 46° S. lat., the aspect changes from rich pasture lands to the dry and sterile regions of Southern Patagonia.

Besides the immense grass-covered region we have now traced, there are two other tracts lying to the north-west of it, bearing the name of *Pampas*, viz., Sacramento and Moxos.

The principal Pampas are the six following:—

*The Pampa del Sacramento* lies in Peru, north-west of Cuzco (13° 30′ S. 71° 20′ W.), between the rivers Huallaga and Ucayali. It is unlike the other Pampas, its soil not being saline, and possessing a more luxuriant vegetation.

*The Pampa de Moxos* is situated to the north of Bolivia, between the rivers Beni and Mamore, and is somewhat similar in character to that just mentioned.

*The Pampa de Huanacos* includes the tract between the forests of Moxos and Campos Parexis on the north, and the river Pilcomayo (a large tributary of the Paraguay) on the south. To the south of this Pampa extends the great desert of Gran Chaco to the bank of the Rio Salado. Between this river and the Dulce, in the south, there are extensive forests, swarming with bees. The last-mentioned river may be said to form the northern boundary of

*The Pampa Cordova*, which is bounded by the Lower Parana in the east, and the Sierra de Cordova on the west. On the north it joins the Sandy Plains of Santiago del Estero, and on the south it merges into the Pampas of Buenos Ayres. This Pampa is traversed by a great number of streams, most of which lose themselves in the sands or marshes, or in lakes without issue, which are here called *Lagunas*. The rivers, lakes, and wells of this district are said to be brackish. The northern and worst part of this plain is known by the name of *Las Salinas*, or the Salt Desert; and to the north and west of the plains of Tucuman there are spaces of many square miles in extent condemned to perpetual sterility. These barren districts are termed *Traversia*, and are covered with sand and stones, and a few saline plants.

*The Pampas of Buenos Ayres* lie between 32° and 40° S. lat., and extend from the base of the Andes to the shores of the Atlantic, embracing an area of about 315,000 square miles. This great plain consists of four distinct regions, exhibiting a diversity of surface, climate, and productions. The first, extending nearly 200 miles to the north-west of the town of Buenos Ayres, is covered with clover and thistles of enormous size. The aspect of this region varies with the changing seasons: in winter the clover is rich and strong, and affords excellent pasturage to numerous herds of cattle. As spring advances the clover gradually disappears, and the thistles extend their leaves over the whole surface of the ground. In a short time they shoot up to the height of ten or eleven feet, in full bloom, and form a luxuriant and impenetrable wood. The heat of summer produces a rapid change in this scene, the thistles droop and fade, their stems become leafless, and rattle one against another with every passing breeze; suddenly the *pampero* levels them with the ground, where they rapidly decompose and disappear; the clover rushes up, and the surface is again spread over with a carpet of the richest green.

The second region, extending for 450 miles to the west of this, is clothed with long luxuriant grass, upon which several thousands of cattle and horses feed. The third region, which reaches to the base of the Cordillera, is a grove of low trees and thorny shrubs, interspersed with patches covered with dry loose stones; numerous swamps abound, with lakes and lagoons formed by the periodical overflowing of the streams which traverse the plain. The fourth region comprises the tract lying to the north and north-east of the *Sierra Ventana*, extending round the *Sierra Tapalguen* to the town of Buenos Ayres. This tract, for the most, consists of fine damp plains, covered with grass, while others are of a soft peaty nature: extensive swamps and lakes, nourishing large beds of reeds, are frequently met with; the dry grounds produce thistles in great abundance.

*The Pampas of Patagonia* is the name sometimes given to that desert region which extends from the Rio Negro to the southern shores of the Continent.

Sir Francis Head has given such an interesting account of the Pampas Indians, that we are induced to give the following extract from his work, entitled "Journeys across the Pampas:"—

"The Indians of whom I heard the most were those who inhabit the vast unknown plains of the Pampas, and who are all horsemen, or rather pass their lives on horseback. The life they lead is singularly interesting. In spite of the climate, which is burning hot in summer and freezing in winter, these brave men, who have never yet been subdued, are entirely naked, and have not even a covering for their head. They live together in tribes, each of which is governed by a Cacique; but they have no fixed place of residence. Where the pasture is good there are they to be found, until it is consumed by their horses, and they then instantly move to a more verdant spot. They have neither bread, fruit, nor vegetables, but they subsist entirely on the flesh of their mares, which they never ride; and the only luxury in which they indulge is that of washing their hair in mare's blood.

"The occupation of their lives is war, which they consider as their noble and most natural employment; and they declare that the proudest attitude of the human figure is when, bending over his horse, man is riding at his enemy. The principal weapon which they use is a spear eighteen feet long; they manage it with great dexterity, and are able to give it a tremulous motion, which has often shaken the sword from the hand of their European adversaries. From being constantly on horseback the Indians can scarcely walk. This may seem singular, but from their infancy they are unaccustomed to it. Living in a boundless plain, it may easily be conceived that all their occupations and amusements must necessarily be on horseback; and from riding so many hours the legs become weak, which naturally gives a disinclination to an exertion which every day becomes more fatiguing; besides, the pace at which they can skim over the plains on horseback is so swift, in comparison to the rate they could crawl on foot, that the latter must seem a cheerless exertion.

"As a military nation they are much to be admired, and their system of warfare is more noble, unincumbered, and perfect in its nature than that of any nation in the world. When they assemble, either to attack their enemies or to invade the country of the Christians, with whom they are now at war, they collect large troops of horses and mares, and then, uttering the wild shriek of war, they start at a gallop. As soon as the horses they ride are tired, they vault upon the bare backs of fresh ones, keeping their best until they positively see their enemies. The whole country affords pasture to their horses, and whenever they choose to stop they have only to kill some mares. The ground is the bed on which from their infancy they have always slept, the flesh of mares is the food on which they have been ever accustomed to subsist, and they therefore meet their enemies with light hearts and full stomachs, the only advantages which they think men ought to desire.

"How different this style of warfare is from the march of an army of our brave, but limping, foot-sore men, crawling in the rain through muddy lanes, bending under their packs, while in their rear the mules and forage, and pack-saddles, and baggage, and waggons and women—bullocks lying on the ground unable to proceed, &c., &c., form a scene of despair and confusion which must always attend the army that walks instead of rides, and that eats cows* instead of horses. How impossible would it be for an European army to contend with such an aërial force! As well might it attempt to drive the swallows from the country as to harm these naked warriors.

"A large body of these Indians twice crossed my path, as I was riding from Buenos Ayres to Mendoza and back again. They had just had an engagement with the Rio Plata troops, who killed several of them, and they were lying naked and dead on the plain not far from the road. Several of the Gauchos who were engaged told me that the Indians had fought most gallantly, but that all their horses were tired, or they could never have been attacked; the Gauchos, who themselves ride so beautifully, declare that it is impossible to ride with an Indian, for that the Indians' horses are better than theirs, and also that they have such a way of urging them on by their cries, and by a peculiar motion of their bodies, that even if they were to change horses the Indians would beat them. The Gauchos all seemed to dread very much the Indians' spears. They said that some of los Barbaros (the Indians) charged without either bridle or saddle, and that in some instances they were hanging almost under the bellies of their horses, and shrieking so that the horses were afraid to face them. As the Indians' horses got tired they were met by fresh troops, and a great number of them were killed.

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* On a long march it seldom happens that the bullocks are able to keep up with our men, whereas the food of the Pampas Indian is always flying before him.

"To people accustomed to the cold passions of England it would be impossible to describe the savage, inveterate, furious hatred which exists between the Gauchos and the Indians. The latter invade the country for the ecstatic pleasure of murdering the Christians, and in the contests which take place between them mercy is unknown. Before I was quite aware of these feelings, I was galloping with a very fine-looking Gaucho who had been fighting with the Indians, and after listening to his report of the killed and wounded I happened, very simply, to ask him how many prisoners they had taken? The man replied by a look which I shall never forgot —he clenched his teeth, opened his lips, and then sawing his fore-finger across his bare throat for a quarter of a minute, bending towards me, with his spur striking into his horse's side, he said, in a sort of low, choking voice, 'Se matan todos" (we kill them all). But this fate is what the Indian firmly expects, and from his earliest youth he is prepared to endure not only death but tortures, if the hard fortune of war should throw him alive among his enemies; and yet how many there are who accuse the Indians of that imbecility of mind which in war bears the name of cowardice! The usual cause for this accusation is, that the Indians have almost always been known to fly from fire-arms.

"When first America was discovered the Spaniards were regarded by the Indians as divinities, and perhaps there was nothing which tended to give them this distinction more than their possessing weapons which, resembling the lightning and the thunder of Heaven, sent death among them in a manner which they could not avoid or comprehend; and although the Christians are no longer considered as divine, yet the Indians are so little accustomed to, or understand the nature of fire-arms, that it is natural to suppose the danger of these weapons is greater in their minds than the reality.

"Accustomed to war among themselves with the lance, it is a danger also that they have not been taught to encounter; for it is well known that men can learn to meet danger, and that they become familiar with its face when, if the mask be changed and it appear with unusual features, they again view it with terror. But even supposing that the Indians have no superstitious fear of fire-arms, but merely consider their positive effects, is it not natural that they should fear them? In Europe, or in England, what will people with sticks in their hands do against men who have fire-arms? Why, exactly what the naked Indians have been accused of doing—run away. And who would not run away?

"But the life which the Indian leads cannot but satisfy any unprejudiced person that he must necessarily possess high courage. His profession is war, his food is simple, and his body is in that state of health and vigour that he can rise naked from the plain on which he has slept, and proudly look upon his image which the white frost has marked out upon the grass, without inconvenience. What can we 'men in buckram' say to this?

"The life of such a people must certainly be very interesting, and I always regretted very much that I had not time to throw off my clothes and pay a visit to some of the tribes, which I should otherwise certainly have done, as, with proper precautions, there would have been little to fear; for it would have been curious to have observed the young sporting about the plains in such a state of wild nature, and to have listened to the sentiments and opinions of the old; and I would gladly have shivered through the cold nights, and have lived upon mare's flesh in the day, to have been a visitor among them.

"From individuals who had lived many years with them I was informed that the religion of the Pampas Indians is very complicated. They believe in good spirits and bad ones, and they pray to both. If any of their friends die before they have reached the natural term of life (which is very unusual), they consider that some enemy has prevailed upon the evil spirit to kill their friend, and they assemble to determine who this enemy can be. They then denounce vengeance against him. These disputes have very fatal consequences, and have the political effect of alienating the tribes from one another, and of preventing that combination among the Indians which might make them much more dreaded by the Christians.

"They believe in a future state, to which they conceive they will be transferred as soon as they die. They expect that they will then be constantly drunk, also that they will always be hunting; and as the Indians gallop over their plains at night, they will point with their long spears to constellations in the heavens, which they say are the figures of their ancestors, who, reeling in the firmament, are mounted upon horses swifter than the wind, and are hunting ostriches. They bury their dead, but at the grave they kill several of their best horses, as they believe that their deceased friend would otherwise have nothing to ride. Their marriages are very simple. The couple to be married, as soon as the sun sets, are desired to lie on the ground with their heads towards the west. They are then covered with the skin of a horse, and as soon as the sun rises at their feet they are pronounced to be married.

"The Indians are very fond of any sort of intoxicating liquor, and when they are at peace with Mendoza, and some of the other provinces, they often bring skins of ostriches, hides, &c., to exchange for knives, spurs, and liquor.

"The day of their arrival they generally get drunk, but before they indulge in this amusement they deliberately deliver up to their Cacique their knives, and any other weapons they possess, as they are fully aware that they will quarrel as soon as the wine gets into their heads. They then drink till they can hardly see, and fight, and scratch, and bite for the rest of the evening. The following day they devote to selling their goods, for they never will part with them on the day on which they resolve to be tipsy, as they conceive that in that state they would be unable to dispose of them to advantage.

"They will not sell their skins for money, which they declare is of no use, but exchange them for knives, spurs, maté, sugar, &c. They refuse also to buy by weight, which they do not understand; so they mark out upon a skin how much is to be covered with sugar, or anything of the sort which they desire to receive in barter for their property. After their business is concluded they generally devote another day to Bacchus, and when they have got nearly sober they mount their horses, and with a loose rein, and with their new spurs, they stagger and gallop away to their wild plains."

## V. *Valleys, Basins, Passes.*

Valleys are the spaces lying between opposite ranges of mountains or hills; their lowest part is generally the *water-course* of some river or torrent which takes its rise in the higher grounds. Valleys occur in almost endless variety; some are broad and open, being formed by the gentle slope of the elevated lands on either side; others are long and narrow, and completely enclosed on all sides by precipitous rocks; others again are basin-shaped, or of a circular form, surrounded by a girdle of mountains.

Those depressions, resembling large clefts or fissures, which occur in mountainous districts, are arranged into two classes, termed *longitudinal* and *transverse* valleys; the former separate the principal parallel ranges, and follow the general direction of the chain; the latter run at various angles with the principal range. Both longitudinal and transverse valleys serve as channels to collect the waters which descend from the mountains, and thus become the beds of streams. Both frequently consist of a succession of terraces or separate basins, and the stream falls from one to another. Those of the transverse valleys are generally frequent and abrupt, and only admit of a mountain torrent, which leaps wildly from stage to stage. The longitudinal valleys usually have longer levels, and less descent, and their streams flow more gently. Valleys situated among steep mountains are sometimes difficult of access, ingress and egress being obtained only by narrow entrances, called *ravines*, *gorges*, *defiles*, or *passes*. These passes, which are often of the most gloomy and terrific aspect, form the only means of communication between the inhabitants on the opposite side of a mountain range. In the Alps they are termed *cols*, some of the highest of which are more than 11,000 feet above the sea, and several of those across the Himalaya and the Hindoo-Koosh reach the astonishing elevation of from 13,000 to 14,000 feet. In some of the deep and precipitous valleys of the Alps and Pyrenees, the rugged projections on each side correspond with such exactness to the angles on the opposite side, as to suggest the idea that the rocks have been severed by some grand natural convulsion.

The valleys situated at a lower level than the class just mentioned are wider and more soft in their features, and gradually lose themselves in the plains. The largest valleys in each of the continents are as follow:—

*Europe.*—The Valley or Plain of Bohemia, consisting of a vast circular basin, presents the appearance of having once been a vast lake. The Canton of the Valais in Switzerland is the largest valley in the Alps, being nearly 100 miles in length, and varying from a quarter of a mile to three miles in breadth; within this area are combined the temperature and vegetation of almost every climate from the Torrid to the Arctic zone. The Valley of the Rhine, between the towns of Basle and Bonn, is bordered by high hills, generally at a small distance from the stream. The Valley of Ordesa, in the Pyrenees, near Mount Perdu, is the deepest in Europe, being about 3,200 feet in depth.

*Asia.*—The beautiful Vale of Cashmere, which is about 80 miles in length and 30 in width, is closed in on either side by the highest ranges of the Himalaya; while these stupendous mountains are covered with perpetual ice and snow, this lovely valley is the seat of luxuriant vegetation, the richest fruits and most beautiful flowers being found in the greatest profusion.

The Upper Valleys of the Jumna and the Ganges narrow as they advance up the precipitous sides of the Himalayan range, until they are at length enclosed by wild masses of rock clothed with snow and glaciers.

*Africa.*—The Valley of the Nile is contracted in Nubia by precipitous rocks on either side to little more than a mile in breadth, and in Upper Egypt only attains the width of a few miles; in Lower Egypt it expands into a broad and open plain.

*America.*—In the regions of the Cordilleras of South America are found valleys of the most magnificent grandeur. There the sides of the wild valleys of Chota and Cutaco are 4,875 and 4,225 feet in perpendicular height, while their breadth is only 2,600 feet; these vast chasms, and others of a similar kind, have their sides covered with a luxuriant vegetation, presenting scenes calculated to impress the traveller with astonishment and awe.

Valleys that lead into longitudinal and transverse valleys are termed *lateral* valleys. Some of these bring down tributary streams from the mountains, and have their sides clothed with luxuriant vegetation. Several of those in the Alps, Pyrenees, and Andes are of exquisite beauty.

*Basins, or circular valleys*, are often occupied by lakes; and in many which are now drained by a river passing through a chasm in the mountain, we find evidence that they were once covered with water, as in Bohemia and Cashmere. Around basins of this kind we frequently observe successive terraces covered with gravel, which seem to have been the shores of the ancient lakes at different periods, called in Scotland parallel roads. Such a road is found at some distance from the southern shores of Lakes Erie and Ontario.

*Passes* are found at various heights, but are generally below the level of the crest, or a little less than half the height of the peaks; so that, at the summits, the walls which bound them rise only 100 or 200 feet above them. In their windings, they are sometimes 1,000 to 2,000 feet in height. The highest known pass is that of Mangrang, in the Himalaya Mountains, 18,500 feet above the level of the sea. The loftiest carriage-road known is that over the Ortler Pass, in Tyrolese Switzerland, 9,000 feet above the sea. The Alps were formerly considered an impenetrable barrier between Italy and Germany; but they were finally crossed by invading armies, and are now traversed by commercial roads. There are six passes over which carriages can be drawn with ease in a few hours, at the height of 6,000 to 7,000 feet above the sea; and Switzerland has become the centre of extensive traffic. In traversing these passes, we find the characteristics of transverse valleys. The traveller generally ascends, by a zigzag or winding course, between walls of rock, sometimes on the edge of a precipice, and sometimes crossing a deep abyss with a torrent roaring beneath him. On reaching the highest point, he descends by a similar passage, accompanied by another torrent, until he comes out with it at the foot of the mountain. Although valleys and passes are much lower than the mountains around, they are often far above the level of the sea and the lowlands, as already stated. The deep valleys of the Upper Rhine and Rhone are from 1,200 to 2,000 feet above the sea. Many of the valleys and passes of the Andes are above the level of most peaks of the Alps; and those of the Himalaya Mountains are loftier than Mont Blanc. Sometimes a transverse valley forms a deep cleft or chasm, called a ravine, defile, dell, or glen. It terminates frequently in a pass; but in other cases it seems to rend asunder the mountain to its base, as in the Notch of the White Mountains in North America. Such openings are sometimes called gates; as the Gates of the Caucasus and the Rocky Mountains.

In some chasms of this kind, the projections on one side correspond so exactly to the cavities on the other, as to make it evident that they must have been rent asunder by some convulsion of the earth far more violent than the earthquakes of modern times. The Andes abound in chasms of a similar kind, called *quebradas*, some of which are nearly a mile in depth. They render travelling dangerous, and are crossed only by bridges of ropes. The Gates of the Rocky Mountains, which form the passage for the Missouri, present a sublime spectacle. The river is only 450 feet broad, and runs for nearly six miles between overhanging precipices, 1,200 feet in height.

### VI. *Deserts.*

The term Desert, in its original sense, means an uninhabited place, and is therefore applicable to many regions conspicuously gifted with natural fertility; it is now, however, used in geography to denote sterile tracts which are occupied by stony or sandy plains, and rendered by the nature of their soil, their want of water, or other causes, unfit for the permanent and settled abode of man. Desert plains, that is, dreary solitudes of stony and sandy wastes, rarely occur in the New Continent, but they occupy an enormous portion of the Old Continent; even some of the best cultivated plains of Europe contain patches of sand of more or less extent. On the western coast of Africa an immense girdle of desert land commences and extends through North Africa, Arabia, Persia, and Central Asia, nearly to the Pacific Ocean.

This vast expanse of irretrievable desolation is for the most part covered with loose shifting sand, which the wind raises into hillocks that are constantly changing their position, and threatening to overwhelm the traveller who may venture across these trackless regions. In some places the surface consists of hills of considerable magnitude, composed of dark and barren limestone rock; in others, beds of gravel appear, furrowed and worn by winter torrents which descend from the higher regions. The more level tracts frequently consist of plains formed of a clayey soil, thinly covered with a short and coarse grass; these often contain extensive salt lakes and marshes, which supply salt in such abundance as to constitute an article of traffic.

The following are the most extensive deserts in the Old and New Continents:—

*The Sahara* (*Săhra*), *or Great Desert*, is the name given to the western portion of that ocean of sand which extends for 800 miles to the south of the Atlas chain, and for 1,000 miles between the Atlantic and the Red Sea. This region is justly regarded as the most barren, parched, and terrific waste upon the globe. The surface of this arid region is occasionally broken by a few rocky hills, or by ridges and hillocks of moving sand. Water is in some cases only found at intervals of between 100 and 200 miles, and then often salt and bitter in its quality. Shallow lakes, impregnated with salts of various kinds, are scattered throughout the Sahara; and in its western parts there are extensive beds of rock-salt of the greatest purity.

The wind, in passing over this ocean of sand, acquires an extraordinary degree of heat and dryness: the heat of a terrible burning wind, called the *Simoom* or *Samiel*, is so great, that it sometimes dries up the water contained in the skins carried by the camels for the use of caravans: in such cases, should the wells fail in a supply of water, men and camels perish of thirst.

During the rainy season, which continues from July to October, a few hollows collect the waters which nourish some shrubs, ferns, and grasses; these, with an aromatic herb resembling thyme, berries, acacias, nettles, and a few thorny shrubs and briars, constitute the only vegetation which is met with in the desert; a grove of date or other palm trees is rarely to be seen, except in the oases. A few monkeys and antelopes content themselves with what little food they can find. Numerous ostriches inhabit this region, feeding upon lizards, snails, and a few coarse herbs. The terrors of this desert are greatly increased by serpents of monstrous size, and enormous lions and panthers that roam about the skirts of theſe dreadful solitudes.

"That lions exist in the desert," says M. Carette, "is a myth popularized by the dreams of artists and poets, and has no foundation but in their imagination. This animal does not quit the mountains, where it finds shelter, food and drink. When the traveller questions the natives concerning these wild beasts, which Europeans suppose to be their companions in the desert, they reply, with imperturbable *sang froid*, 'Have you, then, lions in your country which can drink air and eat leaves? With us lions require running water and living flesh; and therefore they only appear where there are wooded hills and water. We fear only the viper (*lefa*), and, in humid spots, the innumerable swarms of musquitoes which abound there.'"

The Sahara is contracted between the 12° and 16° of east longitude by a wide depression, containing the kingdom of Fezzan, which, although not watered by the permanent flo of any streams, is still sufficiently distinguished from the surrounding deserts to be regarded as a large oasis.

The "Oases" of the desert are a feature too remarkable to be passed unnoticed: these consist of spots insulated amidst the expanse of sand, where a spring of water imparts fertility to a small surrounding district, and renders it often the seat of a numerous population. The oases in the African deserts are depressions below the general level of the plains where they occur; the water which appears in them seems to be derived from more elevated regions further to the south, and to be conveyed through the substratum of clay beneath the hard surface of limestone, and to owe its rise to the removal in those places of the superficial stratum, which enables it to reach the surface. The beauty and fertility which all travellers concur in attributing to the "Oasis of the Desert," may, perhaps, owe some of its features to comparison with the surrounding sterility: but in many respects it doubtless deserves the praises bestowed on it. In the warmer regions of the Old World, the graceful palm-tree, with its taper stem, its long narrow leaves, and its abundant crop of dates, furnishing so many articles of necessity and luxury to the inhabitant of the East, is the constant attendant upon a perennial supply of water; and where the Arab sees the group of palm-trees in the distance, he is sure of a resting-place from toil, and a relief from want.

*The Great Lybian and Nubian Deserts.*—The former of these, which reaches to the banks of the Nile, differs little in character from the Sahara, consisting of an elevated plain, for the most part level and covered with sand, but in some places supporting mountains of limestone formation. The eastern portion of this region is dotted over with natron lakes and numerous oases; the most remarkable of these are the Greater and Lesser Oases in Western Egypt, both of which are in a high state of cultivation. Southward from the Great Oasis to Darfour there is a tract of 700 miles in extent (including the Desert of Bahiouda), which may be passed without meeting a single habitation, except at the beautiful Oasis of Selimah.

To the south, the Libyan Desert joins the sterile region of Northern Nubia; this is divided by the Nile from the Nubian Desert, which occupies the whole space between that river and the Red Sea. This tract consists of a high plain, traversed from north to south by ranges of mountains (attaining in one place 6,000 feet in height), and interrupted by the beds of torrents. Besides these desert regions there is great probability of the existence of similar tracts of large extent in the interior of the southern half of Africa. Eastward, beyond the Red Sea, extend

*The Deserts of Arabia.*—The north-western portion, which is called Arabia Petræa, consists of hard gravelly or rocky plateaus, in some places covered with sand, flints, and rolled stones, interrupted by dark rocks and barren mountains of considerable height, and furrowed by the beds of winter torrents. The appearance of these bare mountains is desolate in the extreme; they terminate to the south in the wild and chaotic mass of the Sinai mountains. These enclose a few fertile valleys that produce grapes, pears, capers, with a few other plants, but the country is in general of frightful sterility, presenting nothing but a few shrubs of Egyptian thorn, which furnishes the *gum arabic* of commerce. Large herds of gazelles wander over this dreary region. Southward, by far the larger portion of the interior of the peninsula consists of immense plains of loose, drifting sand, which produce nothing but a few saline plants. Sometimes a few hilly oases may be seen adorned with a few palm and date trees.

The southern part of these deserts, extending from Mecca to Oman, is called by the native Bedouins "Roba El-Khaly,"—*the empty or deserted abode,*—a name strikingly characteristic of their nature. To the north of Arabia Petræa,

*The Desert of Syria* extends along the southern and eastern borders of Palestine to the Euphrates, and consists of gravel and fine loose sand. In the centre of this desert are the extensive and solitary ruins of Palmyra,—the once magnificent residence of Zenobia.

*The Desert of Mesopotamia,* lying between the rivers Euphrates and Tigris, includes Al-jezireh on the north, and Irak-Arabi, or Babylonia, on the south. The northern half of this desert is still more horrible than those of Africa and Arabia, being generally unproductive, and bearing only coarse grass, thorny shrubs, and vast quantities of wormwood, which banishes all other plants. Its southern portion resembles the delta of Egypt, being covered with a rich alluvial soil which only requires the hand of industry to restore it to its former productiveness, and make it become once more the garden of Asia.

*Deserts of Persia, Afghanistán, and Beloochistán.*—About three-tenths of the surface of Persia is occupied by deserts; the largest of these is the Great Salt Desert, the soil of which

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consists of a stiff clay, covered with a saline efflorescence, and bearing a vegetation of saline plants intermingled with a few pasture lands. The Desert of Afghanistán is a vast sandy basin containing large quantities of salt; that of Beloochistán is of the same character: it does not, however, belong to the Persian table-land, but to the basin of the sea; its vegetation consists in some places of the Indian palm, and aromatic shrubs. Vast tracts of this desert are covered with sand, which the wind blows into ridges like the waves of the sea. A similar desert of moving sand, called the *Desert of Sinde*, extends for a considerable distance along the banks of the Indus, and eastward of that river the *Desert of Thurr* stretches for several miles towards the tributaries of the Ganges.

*The Great Desert of Gobi or Shamo* occupies a considerable portion of the central highland of Asia; the surface of this region, so far as it is known, is covered with a short, thin grass, and contains numerous lakes and springs in which the water, owing to the saline quality of the soil, is so brackish as to be scarcely drinkable: the lowest portions are covered with sand, and abound in salt, and a space of twenty miles in extent, immediately beyond the Chinese wall, consists of sinking and shifting sand, raised into waves by the action of the wind.

*The North American Deserts* strikingly resemble those of Asia and Africa. To the south of the basin of the Columbia river, between the Sierra Nevada of California and the Rocky Mountains, is the Great American Desert, which consists of vast plains of sand and gravel, scantily covered with herbage, but destitute of trees. An extensive tract of desert also occurs in the elevated country which has already been indicated as extending along the eastern side of the Rocky Mountains, and occupies an average width of about 400 miles. In its eastern parts the soil consists of fine sand; further to the west of gravel, having in general a level surface, although rocky masses of considerable height are scattered over it; most of the rivers which cross it are dry during the summer season, and the only vegetation consists of a few hardy plants; beds of rock salt and salt springs also occur in some places.

*South American Deserts.*—The sandy deserts of "Campos Parexis" surrounds the head waters of the Paraguay river; and southward, at some distance from the western banks of that river, there extends another sandy desert, called "El Gran Chaco." To the west of this lies the salt desert of "Las Salinas." About the 40th parallel of south latitude commences the great Shingle Desert of Patagonia, which extends for 800 miles until it sinks into the ocean at the southern extremity of the Continent.

*The Desert of Atacáma.*—Atacáma is a district belonging to the department of Potosi in Bolivia, in South America, and comprehends all the country of that republic which lies to the west of the Andes along the Pacific Ocean. It is divided into Upper and Lower. The Lower country presents over nearly all its surface nothing but an uninhabited and uninhabitable desert, consisting of wide plains covered with a dark brown, and in some places quite black sand, with here and there a streak of white. On the plains rise some high ridges and a few immense rounded knolls, but in no part are any traces of vegetation to be discovered. This description is particularly applicable to the southern part, which extends towards the boundary of Chili, in which many Spaniards perished for want of water at the time of the first conquest, and which is known under the name of the desert of Atacáma.

Omitting the interior regions of Australia, the vast districts of arid sandy deserts which we have just traced, with the sandy patches in Europe, cover an area of perhaps not less than five or six millions of square miles, an extent half as much again as the whole of Europe, and more than forty times the area of Great Britain. This immense portion of the earth's surface seems condemned to perpetual sterility.

We shall conclude this article by introducing some beautiful passages on steppes and deserts from Humboldt's 'Views of Nature.'

"At the foot of the lofty granitic range which, in the early age of our planet, revisited the irruption of the waters on the formation of the Caribbean Gulf, extends a vast and boundless plain. When the traveller turns from the Alpine valleys of Caraccas, and the island-studded Lake of Nicaragua, whose waters reflect the forms of the neighbouring bananas, when he leaves the fields verdant with the light and tender green of the Tahitian sugar-cane, or the sombre shade of the cacao groves, his eye rests in the south on steppes, whose seeming elevations disappear on the distant horizon.

"From the rich luxuriance of organic life, the astonished traveller suddenly finds himself on the dreary margin of a treeless waste. . . Like a limitless expanse of waters, the steppe fills the mind with a sense of the infinite. . . . But the aspect of the ocean, its bright surface diversified with rippling or gently swelling waves, is productive of pleasurable sensations,—while the steppe lies stretched before us, cold and monotonous, like the naked stony crust of some desolate planet.

"In all latitudes, nature presents the phenomenon of these vast plains, and each has some peculiar character or physiognomy, determined by diversity of soil and climate, and by elevation above the level of the sea.

"In northern Europe, the heaths which, covered by one sole form of vegetation to the exclusion of all others, extend from the extremity of Jutland to the mouth of the Scheldt, may be regarded as true steppes. . . .

"The plains in the interior of Africa present a grander and imposing spectacle. Like the wide expanse of the Pacific, they have remained unexplored until recent times. They are portions of a sea of sand, which towards the east separates fruitful regions from each other, or encloses them like islands, as the desert near the basaltic mountains of Harudsch, where, in the oasis of Siwah, rich in date-trees, the ruins of the Temple of Ammon indicate the venerable seat of early civilisation. Neither dew nor rain refreshes these barren wastes, or unfolds the germs of vegetation within the glowing depths of the earth; for everywhere rising columns of hot air dissolve the vapours and disperse the passing clouds.

"Wherever the desert approaches the Atlantic Ocean, as between Wadi Nun and the White Cape, the moist sea air rushes in to fill the vacuum caused by these vertically ascending currents of air. The navigator, in steering towards the mouth of the river Gambia, through a sea thickly carpeted with weeds, infers, by the sudden cessation of the tropical east wind, that he is near the far-spreading and radiating sandy desert.

"Flocks of swift-footed ostriches and herds of gazelles wander over this boundless space. With the exception of the newly-discovered group of oases, rich in springs, whose verdant banks are frequented by nomadic tribes of Tibbos and Tuaricks, the whole of the African deserts may be regarded as uninhabitable by man. It is only periodically that the neighbouring civilized nations venture to traverse them. On tracks whose undeviating course was determined by commercial intercourse thousands of years ago, the long line of caravans passes from Tafilet to Timbuctoo, or from Mourzouk to Bornou; daring enterprises, the practicability of which depends on the existence of the camel, *the ship of the desert*, as it is termed in the ancient legends of the east.

"On the mountainous range of Central Asia, between the Gold or Altai Mountain and the Kuen-lun, from the Chinese Wall to the further side of the Celestial Mountains, and towards the Sea of Aral, over a space of several thousand miles, extend, if not the highest, certainly the largest steppes in the world. . . The vegetation of the Asiatic steppes, which are sometimes hilly and interspersed with pine forests, is in its groupings far more varied than that of the Llanos and the Pampas of Caraccas and Buenos Ayres. The more beautiful portions of the plains, inhabited by Asiatic pastoral tribes, are adorned with lowly shrubs of luxuriant white-blossomed rosaceæ, crown imperials (fritillariæ), cypripedeæ, and tulips. As the torrid zone is in general distinguished by a tendency in the vegetable forms to become arborescent, so we also find, that some of the Asiatic steppes of the temperate zone are characterized by the remarkable height to which flowering plants attain; as, for instance, saussureæ, and other synanthereæ, all siliquose plants, and particularly numerous species of astragalus. On crossing the trackless portions of the herb-covered steppes in the low carriages of the Tartars, it is necessary to stand upright in order to ascertain the direction to be pursued through the copse-like and closely crowded plants that bend under the wheels. Some of these steppes are covered with grass; others with succulent, evergreen, articulated alkaline plants; while many are radiant, with the effulgence of lichen-like tufts of salt, scattered irregularly over the clayey soil like new-fallen snow. . . .

"Like the greater part of the Desert of Sahara, the Llanos, the most northern plains of South America, lie within the torrid zone. Twice in every year they change their whole aspect, during one-half of it appearing waste and barren like the Libyan desert; during the other, covered with verdure, like many of the elevated steppes of Central Asia."

## VII. *Islands.*

The islands evidently are one of the most interesting characteristics of the oceans. They are the tops of mountains or table-lands, whose base is in the bed of the ocean, and whose valleys and passes are filled with its waters. They have all the varieties of situation and appearance which belong to mountains; some rising alone, like insulated mountains, as the celebrated rock of St. Helena, others arranged in groups, and others still in chains. Small islands are sometimes mere rocks, scantily covered with soil, without rivulets, and often without springs. Large islands are only continents in miniature; and each has its own system of mountains, valleys and streams.

The same variety of structure is found in islands as in hills and mountains. Some are composed of rocks varying in form according to their class; others consist of mere banks of sand, or alluvial beds, thrown up by the sea, or by the current of a river. Sometimes the elevations on the bed of the ocean are not high enough to reach the surface, or to be covered by every tide, in which case they seem like imperfect islands. If they are flat and broad, they are called *shoals* or *banks;* if they form a range of rocks, they are called a *reef.*

Round or elliptical islands are generally found in the midst of the sea, either alone or in groups, as in the Pacific. These often become the rendezvous of mariners to which they resort for fresh supplies, as St. Helena, the Sandwich Islands, &c. There are two classes of islands to be distinguished; the *continental islands,* which their proximity, their size, their geological character, their forming a line with the mountain chains of the firm land, prove to be a dependence of the continents; and the *pelagic,* or *oceanic islands,* dispersed singly or in groups, at a distance from the lands, over the vast surface of the ocean, of small dimensions, and always of a volcanic or coralline character.

The Pacific Ocean is far the richest in islands, whether continental or pelagic. The Indian archipelago and that of New Holland is the largest continental archipelago existing on the surface of the globe; and the thousands of pelagic islands with which the centre of this ocean is studded have nowhere else their parallel.

The Atlantic Ocean possesses still in the group of the Antilles, the British Islands, and those of the Mediterranean, continental archipelagos of great importance; but the pelagic islands are thinly represented there by the groups of the Azores, Madeira, the Canaries, Cape Verd, St. Helena, and some other small islands lost in the midst of the ocean.

The Indian Ocean is scanty in both. Madagascar and Ceylon, one by the main land, represent the continental islands. Here and there a few volcanic islands, as Mauritius and Bourbon, represent the pelagic.

*Continental Islands* have manfest relation to the continents to which they belong; they are merely fragments of their respective continents, from which they have been torn asunder by some great convulsion. Thus a chain of continental islands extends along the eastern coast of Asia, from Kamtschatka to Malacca; others bend around the shores of New Holland, the northern coast of South America, around the shores of North America, and the north-western coast of Africa. The British Isles are merely detached portions of the continent of Europe. The coasts of Norway, Denmark, Holland, Greece, and the United States of North America, are fringed with small island chains. Several of the continental islands serve rather as supplements and outposts to the continents, for the defence as well as for the extension of commerce and civilization. Such has been the influence of Sicily, Ceylon, the West Indies, and above all the Grecian and British Islands. A few however are almost uninhabitable from their inacessible shores, barren soil, and unfavourable climate.

Several of the pelagic, or oceanic islands, in the Pacific and Atlantic Oceans, appear to have been upheaved by volcanic agency from the depths of the ocean, whilst others are the results of the peaceful labours of the coral insect.

The manner in which the coral reefs are converted into islands is very singular. As the coral animals cannot exist above the surface of the ocean, they are unable to raise themselves by their own efforts above the level of the lowest tides; when the reef therefore is of such a height that it remains almost dry at low water the corals leave off building: at this elevation the reef presents the appearance of a continuous mass of solid stone, composed of shells, broken-off prickles, and fragments of coral, the whole being bound together by the sand produced by the pulverization of the shells. The heat of the sun now splits in many places the dry mass of stone; the waves also separate and lift large blocks of coral, throwing them upon the reef. In this way the ridge gradually increases in altitude until it reaches a height of 10 or 12 feet; it is then covered only during some seasons of the year by the spring-tides. Having thus surmounted the sea, trunks of trees and other drift wood, brought by currents from distant countries, are arrested and augment the mass. The sand, which is of a dazzling whiteness, now lies undisturbed, and offers to the seeds of cocoa, and other trees and plants floated thither by the waves, a soil on which they rapidly grow. Each returning tide contributes its share of sea-weed, dead shell-fish, branches of trees, and other materials towards the formation of the new structure. Bushes and stately palms now shoot up; sea-fowl and birds find refuge and nestle there; and, last of all, man comes and takes possession of this newly-created country.

Captain Basil Hall, in his 'Voyage to Loo-choo,' has recorded some pleasing observations on coral islands. He says, "The examination of a coral reef during the different stages of one tide is particularly interesting. When the sea has left it for some time it becomes dry, and appears to be a compact rock exceedingly hard and rugged; but no sooner does the tide rise again, and the waves begin to wash over it, than millions of coral worms protrude themselves from holes on the surface which were before quite invisible.

"These animals are of a great variety of shapes and sizes, and in such prodigious numbers, that in a short time the whole surface of the rock appears to be alive and in motion.

"The most common of the worms at Loo-Choo was in the form of a star, with arms from four to six inches long, which it moved about with a rapid motion in all directions, probably in search of food. Others were so sluggish that they were often mistaken for pieces of the rock: these were generally of a dark colour, and from four to five inches long and two or three round. When the rock was broken from a spot near the level of high water it was found to be a hard solid stone; but if any part of it were detached at a level to which the tide reached every day, it was discovered to be full of worms, all of different lengths and colours, some being as fine as thread and several feet long, generally of a very bright yellow, and sometimes of a blue colour; while others resembled snails, and some were not unlike lobsters and prawns in shape, but soft, and not above two inches long.

"The growth of coral ceases when the worm which creates it is no longer exposed to the washing of the tide. Thus a reef rises in the form of a gigantic cauliflower till its top has gained the level of the highest tides, above which the worm has no power to carry its operations, and the reef, consequently, no longer extends itself upwards. The surrounding parts, however, advance in succession till they reach the surface, where they also must stop. Thus, as the level of the highest tide is the eventual limit to every part of the reef, a horizontal field comes to be formed coincident with that plane, and perpendicular on all sides. The reef, however, continually increases, and, being prevented from going higher, must extend itself laterally in all directions; and this growth being probably as rapid at the upper edge as it is lower down, the steepness of the face of the reef is preserved, and it is this circumstance which renders this species of rock so dangerous in navigation. In the first place, they are seldom seen above the water; and in the next, their sides are so abrupt that a ship's bows may strike against the rock before any change of soundings indicates the approach of danger."

For a long time it was supposed that the coral formations were raised from the floor of the fathomless ocean by the unaided efforts of these little creatures; but more accurate observations have proved that the animals cease to live at a greater depth than 20 or 30 fathoms. Mr. Darwin, in his elaborate treatise on coral reefs, has advanced and ably supported the theory, that these islands were originally of the common rock formation, and that the coral animals have fixed their stony habitations on the shelving sides of the rock, a few fathoms below water, from which point they have worked up to the surface of the ocean, and that however varied the altitude of these rocks may have been, they are now reduced to a uniform level by the gradual subsidence of the loftiest points and the successive cappings of coral upon the less elevated summits. "It is improbable," says he, "in the highest degree, that broad, lofty, isolated, steep-sided banks of sediment, arranged in groups and lines hundreds of leagues in length, could have been deposited in the central and profoundest parts of the Pacific and Indian Oceans, at an immense distance from any continent, and where the water is perfectly limpid. It is equally improbable that the elevatory forces should have uplifted throughout the above vast areas innumerable great rocky banks within 20 to 30 fathoms, or 120 to 180 feet, of the surface of the sea, and not one single point above that level; for where on the whole face of the globe can we find a single chain of mountains, even a few hundred miles in length, with their many summits rising within a few feet of a given level, and not one pinnacle above it? If then the foundations, whence the atoll-building corals sprang, were not formed of sediment, and if they were not lifted up to the required level, they must of necessity have subsided into it; and this at once solves the difficulty. For as mountain after mountain, and island after island, slowly sank beneath the water, fresh bases would be successively afforded for the growth of the corals. It is impossible here to enter into all the necessary details, but I venture to defy any one to explain in any other manner how it is possible that numerous islands should be distributed throughout vast areas—all the islands being low—all being built of corals, absolutely requiring a foundation within a limited depth from the surface."

But as some of the islands of the Pacific are elevated 200 and 300 feet above the sea level, it is evident that they must have been raised by submarine forces; in short, that the volcano and the earthquake must have been employed in rearing them to their present elevation. Mr. Darwin has traced those regions throughout the Pacific, in which upheaval and depression alternately prevail. Thus a band of *atolls* and encircled islands, including the Dangerous and Society Archipelagos, constitutes an area of subsidence more than 4,000 miles long and 600 broad. To the westward, the chain of *fringing reefs*, embracing the islands of the new Hebrides, Solomon, and New Ireland, form an area of elevated coral. Further westward, another area of subsidence is met with, including the islands of New Caledonia and the Australian barrier.

The Pacific and Indian Oceans, for 30° on each side of the equator, are extremely productive of coral. Between the coast of Malabar and Madagascar there is a chain of coral reefs called the Maldives and Laccadives, extending due north and south for nearly 480 geographical miles, with an average width of about 50 miles. On the east coast of Australia an unbroken reef stretches for 350 miles; and between that country and New Guinea, coral formations extend throughout a distance of 700 miles, interrupted by no interval exceeding 30 miles in length.

Of thirty-two of the coral islands visited by Beechy in his voyage to the Pacific, twenty-nine had lagoons in their centres. The largest was 30 miles in diameter, and the smallest less than a mile. All were increasing their dimensions by the active operations of the lythophytes, which appeared to be gradually extending and bringing the immersed parts of their structure to the surface. The scene presented by these annular reefs is equally striking for its singularity and beauty. A strip of land a few hundred yards wide is covered by lofty cocoa-nut trees, above which is the blue vault of heaven. This band of verdure is bounded by a beach of glittering white sand, the outer margin of which is encircled with a ring of snow-white breakers, beyond which are the dark heaving waters of the ocean. The inner beach encloses the still clear water of the lagoon, resting in its greater part on white sand, and, when illuminated by a vertical sun, of a most vivid green.*

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* Darwin's Journal, &c., p. 540, and new edit. of 1845, p. 453.

Certain species of zoophytes abound most in the lagoon, others on the exterior margin, where there is a great surf. "The ocean," says Mr. Darwin, "throwing its breakers on these outer shores, appears an invincible enemy, yet we see it resisted and even conquered by means which at first seem most weak and inefficient. No periods of repose are granted, and the long swell caused by the steady action of the trade wind never ceases. The breakers exceed in violence those of our temperate regions, and it is impossible to behold them without feeling a conviction that rocks of granite or quartz would ultimately yield and be demolished by such irresistible forces. Yet these low insignificant coral islets stand and are victorious, for here another power, as antagonist to the former, takes part in the contest. The organic forces separate the atoms of carbonate of lime one by one from the foaming breakers, and unite them into a symmetrical structure; myriads of architects are at work night and day, month after month, and we see their soft and gelatinous bodies through the agency of the vital laws conquering the great mechanical power of the waves of an ocean, which neither the art of man, nor the inanimate works of nature could successfully resist."[*]

An immense belt of the Pacific Ocean, for nearly 5,000 miles in length, and 1,500 in breadth, is so studded with islands as to form almost one continuous archipelago. The islands are of three distinct forms, the *coral*, the *crystal*, and the *volcanic*: the first greatly predominates; of the crystal formation but few specimens are known, but the last are of the largest description: these will be noticed in the next section.

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[*] Darwin's Journal, &c., pp. 547, 548, and new edit. of 1845, p. 460.

# CHAPTER VI.

## VOLCANIC PHENOMENA.

### *Earthquakes. Volcanoes.*

THE term Volcano (derived from Vulcanus, the name given by the Romans to their imaginary god of fire) is applied to those mountains which send forth from their summits or sides, flame, smoke, ashes, and streams of melted matter called lava; it is also applied to mountains having eruptions of mud only, and which are hence called Mud Volcanoes.

Volcanoes have not the same permanency of character as other features of the globe. They are, in fact, only mountains which are subject to the action of internal fire, and their number and character are liable to continual change from its effects. The activity of this fire, and the approach of an eruption where a volcano exists, are generally announced by earthquakes, and the terrifying phenomena which precede them. Earthquakes are often preceded by great stillness of the air, and unusual agitation of the waters. The sea swells and roars, without wind. Sometimes it rises and sinks alternately, laying bare the coast at one moment, and overflowing the land at the next. The springs and wells are frequently agitated, and send forth muddy and impure water, or become dry. Deep rumbling noises, like that of carriages on a rough pavement, or tremendous explosions, like the discharge of cannon, are often heard immediately before the shock.

The first shock of an earthquake seldom lasts longer than a minute, and frequently completes the most awful destruction in this short period. The ground suddenly heaves upward, or is rocked from side to side, with successive vibrations, overthrowing the feeble structures erected by man. Chasms are occasionally opened in the earth, from which smoke and flame, or torrents of water, burst forth. In some cases they have been so extensive that large cities have sunk down in a moment, as was the fact with the cities of Euphemia, in Southern Italy, and Port Royal, in Jamaica. Shocks of this kind frequently succeed each other, at intervals, for days, or even weeks, before the eruption of a neighbouring volcano; and in some instances, where no volcanic eruption takes place, for much longer periods.

Where a volcano exists, columns of smoke next begin to issue from its top, and then tremendous explosions, flashes of flame, and showers of red-hot stones, or ashes, burst forth from the crater. At length, a stream of melted stones, or lava, resembling the slag of a furnace, breaks out from the top, or more commonly from the side, of the mountain, and flows, like red-hot melted metal, in a sluggish but destructive stream of fire. It is often followed by showers of ashes and fragments of rocks, and these are sometimes in sufficient quantity to darken the air. Thus an eruption has buried whole cities, as Herculaneum and Pompeii, near Naples, in Italy. The city of Herculaneum was buried in the lava, and the city of Pompeii in the ashes, of Vesuvius, during its eruption 79 years before the birth of Christ. Both cities have been partially dug out, and the remains of their inhabitants discovered. In the eruption of Tamboro, in the East India island of Sumbawa, in 1815, the showers of ashes produced total darkness in that island for 22 hours, and at Madura, 350 miles distant, for 19 hours. The explosions were heard at the Spice islands 800 miles distant. The ordinary streams of lava spread into fields, and soon congeal into a hard black slag on the surface, so that they can be crossed on foot, while the interior remains red-hot for a long period.

Some volcanoes, like those of Macaluba, in Sicily, throw out only mud, by the explosion of confined gas or air. The lofty volcanoes of South America and Mexico seldom throw out lava, but produce their most destructive effects by torrents of hot water and mud, which have overwhelmed 40,000 persons in a single eruption. These torrents sometimes contain fishes from subterraneous waters. The gas which issues from such volcanoes, and sometimes from many openings in volcanic regions, is often inflammable, and maintains a perpetual flame, as in the "fields of fire," as they are termed by the natives connected with the burning springs of naphtha, near the Caspian Sea. Eruptions are most frequent in volcanoes of moderate elevation. A few blaze continually, like Stromboli, one of the Lipari Isles, which is called "The great lighthouse of the Mediterranean," and the Kilanea, in the Sandwich Islands, one of the most remarkable volcanoes in the world. But in most volcanoes eruptions take place only at intervals, and, for a great length of time, nothing but smoke issues from them, accompanied, in some cases, by a stream of lava oozing slowly from the side.

Some volcanoes have become dormant or extinct. Some emit only sulphureous and other vapours, and are called solfataras (sulphur grounds), or fumeroles (smoke vents). On the other hand, new volcanoes have broken out within the memory of man, and even within a few years, especially in the sea. Among these, was Sabrina Island, near the Azores, in 1811; and in 1814, another in the Aleutian Islands. Vesuvius has sometimes slumbered for a century. The eruptions of the Peak of Teneriffe, which is among the highest volcanoes, have been rare for several centuries. Six volcanoes, of considerable size, rose on the plain of Malpays, or Jorullo, in Mexico, in 1759; and since 1811, several volcanoes have burst out in the sea. More than 300 volcanoes are known to exist in the world, one half of which are in America; but many of them have never been described, and have scarcely received a name in works of geography.

The volcanoes of Europe and Asia are generally on islands; but those of America are chiefly on the main land; as will be seen in the following statement of the number of volcanoes and solfataras known:—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Europe, | on | the continent, | 4; | on islands, | 20; | total, | 24 |
| Asia, | ,, | ,, | 17 | ,, | 29 | ,, | 46 |
| Africa | ,, | ,, | 2 | ,, | 9 | ,, | 11 |
| America | ,, | ,, | 86 | ,, | 28 | ,, | 114 |
| Polynesia | ,, | ,, | – | ,, | 108 | ,, | 108 |
| Total known – – – | | | 109 | | 194 | | 303 |

Some volcanoes stand alone, or form the centre of a volcanic region; like Etna, Vesuvius, and the volcanoes of Iceland, the Azores, and the Sandwich Islands. Most of the islands and island groups of the Atlantic, Pacific, and Indian Oceans, are volcanic in their character, and of this kind, and are termed central volcanoes.

Earthquakes and volcanic eruptions generally occur nearly in alternate periods. In the region of a volcano the shocks are most violent at the greatest distance from it, and before an eruption, and generally cease when it begins. We must therefore prescribe both to one common cause—the expansion, or explosion, of gases and vapours, produced by heat, as in the bursting of a cannon, or of the boiler of a steam-engine. Hence we perceive, also, that volcanoes are the safety valves through which these vapours find vent, and must recognise the goodness of the Creator, even in their terrible eruptions, which prevent the more dreadful and extensive destruction of earthquakes. At the same time, we see in both some of the most striking exhibitions of his power. "He looketh on the earth, and it trembleth. He toucheth the hills, and they smoke."

The mighty and shattering energy of volcanic power is the most frightful and majestic of all the phenomena connected with our globe. The violent moving of the earth, the low rumbling of the subterranean thunder, and the shaking of the mountain, first announce the invisible war of the elements. Volcanic action is distinctly the exponent of some great physical law connected with the general structure of the earth. It has been known to distort plains, raise mountains where none stood before, and, in some instances, mountains have altogether disappeared. In 1759, in one fearful night of convulsion, a new mountain (Jorullo) in Mexico was upheaved to the height of 1,695 feet, and the country for three or four miles around was swelled like an inflated bladder. The effects of volcanic energy are widely diffused over the earth's surface, being altogether independent of latitude or differences of climate.

"There are large spaces where there is abundant evidence that the subterranean fire is at work continuously, for the ground is convulsed from time to time by earthquakes; gaseous vapours (especially carbonic acid gas) are disengaged plentifully from the soil; springs often issue at a very high temperature, and their waters are usually impregnated with the same mineral matters as are discharged by volcanoes during eruptions."* But to describe these districts would be beyond the limits of a work of this nature; we shall therefore briefly notice those regions in which active vents and extinct craters exist. One great fact connected with the distribution of volcanoes is, that by far the greater number are situated on islands or sea-coasts. Of active volcanoes two hundred and twenty-seven have been numbered, of which twenty-eight are doubtful, and of extinct volcanoes, one hundred and twenty-nine have been counted, of which forty-one are doubtful. The following is a simple classification of the regions visited by volcanic action:—

*American Volcanic Districts.*—In South America, the mighty range of the Andes from lat. 43° S. to about 2° N. exhibits an enormous volcanic system. In this chain no less than forty-six volcanoes have been enumerated, forty-one of which are said to be in action; some of these, as Cotopaxi, Antisana, Tunguragua, and other huge cones, are of prodigious grandeur and of frequent activity. Only one active volcano occurs in Peru, but in Chili there are nineteen active at frequent intervals, one of which (Villarica) burns almost uninterruptedly.

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* Sir Charles Lyell's 'Principles of Geology.'

In North America, to the north of the Isthmus of Panama, throughout Guatemala or Central America and Mexico, there are forty-seven volcanoes, thirty of which are active. Five of these (Tuxtla, Orizaba, Popocatepetl, Jorullo, and Colima) traverse Mexico in the direction from east to west, and therefore at right angles to the great volcanic chain. Further northward, in the peninsula of California and on the north-west coast of North America, there are five active and five extinct volcanoes, and in the West India islands there are three active and eight extinct.

*Asiatic Volcanic Districts.*—The northern extremity of the volcanic region of America is continued into Kamtschatka by the peninsula of Aliaska and the Aleutian Archipelago, in which latter there are cones of great elevation. In the peninsula of Kamtschatka there are several magnificent active volcanoes; these are prolonged in a southerly direction by the Kurile chain of volcanic mountains, nine of which are known to have been in eruption; the line is still continued southward in the islands of Japan, where the number of burning mountains is very great. The communication is preserved by several volcanic isles between the Japanese and Philippine Islands, where the subterranean energies are still unsubdued, and constitute a band of lofty islands and promontories extending through the Molucca and Sunda Islands to Barren Island, in the Bay of Bengal.

In Central and Western Asia, detached points appear, which at one period must have been the seats of volcanic action, as in the Thian-shan or Celestial Mountains, in the mixed active and extinct volcanic mountains around the Persian Gulf, in the regions adjacent to the Caspian Sea, including Demavend, the mountains of Armenia (especially Ararat), and the Caucasus, in the Red Sea, in the Dead Sea, and in the "Catakecaumene" or burnt-up region in the west of Asia-Minor.

*African Volcanic Districts.*—These are chiefly confined to the islands, nearly all of which are volcanic, though their activity has long since ceased, as in St. Helena and the Canary

Isles, which, though long devastated, now enjoy rest through the safety-valve of Teneriffe.

The traces of volcanic action in the continent appear in the chain of the Atlas, and in the tracts adjoining the Red Sea.

*The European Volcanic Districts* comprise the Greek islands of Melos and Santorin, which bear evident marks of having at some distant period been the outlets of fires. Proceeding westward, volcanic rocks are met with in Styria, Transylvania, Hungary, Central Germany, and in certain localities along the Rhine. They are also met with in Northern and Central Italy. The southern portion of the Italian peninsula, and the adjacent islands, assume a terribly volcanic character; Vesuvius in the district of Naples, Etna in Sicily, and Vulcanello in the Lipari Isles, have all been subject to frequent and violent action, whilst Chicciola, in the island of Stromboli, never ceases to emit smoke or flame. The islands of Ischia and Procida are of volcanic character. In the centre of France (in Auvergne, the Vivarais, &c.), upwards of one hundred domes of extinct volcanoes have been numbered, and several volcanic rocks have been met with in the Spanish peninsula. In the Azores (a small group of islands in the Atlantic, lying about 800 miles to the west of Portugal), new islands have been thrown up, and some have disappeared.

The Western Isles of Scotland exhibit traces of volcanic action.

In Iceland, amid the regions of everlasting snow, there burns a perpetual fire, which in many parts bursts forth in the most strange and terrific manner. The striking characteristics of this island are its flaming volcanoes (Hecla and many others), and its geysers, or boiling springs.

*Volcanic Isles of the Pacific.*—In the Pacific Ocean there are abundant traces of volcanic energy; the island groups comprising Banda, New Guinea, New Britain, the New Hebrides, Norfolk Island, and St. Philip, the Friendly, the Society, the Ladrone, and the Sandwich Islands, from the bold and irregular form of their rocky mountains, show that they have been uplifted from the bed of the ocean by the resistless action of the fire. In the two latter groups there are two active volcanoes of great elevation.

"Mr. Darwin has with great ingenuity developed the genetic connexion between shore-reefs, island-encircling reefs, and lagoon islands, *i. e.*, narrow, annular coral banks which surround inner lagoons. According to his views, these three kinds of structure depend upon the oscillating condition of the bottom of the sea, or on periodical elevations and subsidences. The following, he considers, is the process of formation. An island mountain, closely encircled by a coral reef, subsides, while the fringing reef that had sunk with it is constantly recovering its level, owing to the tendency of the coral animals to regain the surface by renewed perpendicular structures. These constitute, first, a reef encircling the island at a distance, and, subsequently, when the enclosed island has wholly subsided, an atoll. According to this view, which regards islands as the most prominent parts, or the culminating points, of the submarine land, the relative position of the coral islands would disclose to us what we could scarcely hope to discover by the sounding line, viz., the former configuration and articulation of the land. This attractive subject can only be fully elucidated when we shall succeed in acquiring further knowledge of the depth and nature of the different rocks which serve as a foundation for the lower strata of the dead polyp-trunks." *

"It appears, then, as the general conclusion with regard to this subject, that when these two great types of structure, namely, barrier-reefs and atolls on the one hand, and fringing reefs on the other, are thus laid down in colours on map, a magnificent and harmonious picture of the movements which the crust of the earth has within a late period undergone, is presented to us. We there see vast areas rising, with volcanic matter every now and then bursting forth through the vents or fissures with which they are traversed. We see other wide spaces slowly sinking without any volcanic outbursts ; and we may feel sure, that this sinking must have been immense in amount, as well as in area, thus to have buried over the broad face of the ocean every one of those mountains, above which atolls now stand like monuments, marking the place of their former existence. Reflecting how powerful an agent, with respect to denudation, and, consequently, to the nature and thickness of the deposits in accumulation, the sea must ever be, when acting for prolonged periods on the land, during either its slow emergence or subsidence; reflecting, also, on the final effects of these movements in the interchange of land and ocean—water, on the climate of the earth, and on the distribution of organic beings, it may be fairly assumed, that the conclusions derived from the study of coral formations are

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* Humboldt's 'Aspects of Nature.'

amongst the most important that can be presented to the consideration of the physical geographer."

Some of the great purposes fulfilled in the economy of nature by the operations of volcanoes are thus pointed out by Dr. Daubeny, in his excellent work on volcanoes.

"Whatever may have been the end for the sake of which an accumulation of inflammable materials in the interior of our globe was ordained, their existence there, under circumstances which admitted of their undergoing from time to time inflammation, may teach us to regard the production of volcanoes not only as natural consequences, but even as useful provision. "They are the chimneys, or rather the safety-valves, by which elastic matters are permitted to discharge themselves, without causing too great a strain upon the superficial strata.

"It has been wisely arranged that plants can exist in an atmosphere more impregnated with carbonic acid than animals can do, and that amongst plants those kinds which approach nearest in form and organization to the ones which lived during the period of the coal formation are most tolerant of an excess of this ingredient. Nevertheless, there is doubtless a point beyond which the addition of carbonic acid to the air could not proceed without the extinction of every kind of life; and hence it is probable that the whole amount of carbon which is now fixed in animals and vegetables, dead or alive, in our coal basins, as well as in our forests, was never at any one time present as carbonic acid in the atmosphere.

"There seems a much greater probability that it was gradually supplied, in proportion to the demand, by volcanoes, which, as we have seen, are at the present time vomiting forth very large quantities of this gas, even at times when to an ordinary observer they appear to be extinguished. Whilst coral animals and mollusca of various kinds are continually adding to the amount of carbonate of lime at the bottom of what is now the sea, but which will one day, doubtless, form dry land, volcanoes, on the other hand, are employed in redressing the balance, by expelling the carbonic acid from lime-stones of older date, and forming rocks of silicate of lime in the place of those composed of carbonate. In short, volcanoes appear to be the agents for bringing up to the surface those ingredients which lie deep within the bowels of the earth, and which might have been there for ever locked up, had it not been for its deep-seated and explosive energy."

# CHAPTER VII.

## DISTRIBUTION OF MINERALS.

THE general structure of the earth and features of its surface have been described in the preceding chapters, and we are now prepared for an account of the most useful and valuable minerals which are found among its rock formations.

*Minerals* are not distributed on the earth according to climates, like animals and vegetables; but, by the kindness of Providence, those which are most necessary to man are found in almost all countries; and others are more or less abundant, according to their importance. It is remarkable, also, that the most barren portions of the earth are often most plentiful in mineral treasures.

The *metals* are sometimes found pure, but they are generally mixed with other minerals, in a stony substance, termed *ore*. They are found occasionally in beds, or large masses, but usually in veins, passing through rocks. The veins vary in width, from a few inches to many feet. Sometimes they extend many miles in length, varying in breadth in different parts. Their depth is often very great, but they are often neglected, because the ore is too poor, or the digging too expensive. Coal, salt, and iron, are frequently found in beds of great extent, but usually of no great depth. In digging an excavation, or mine, to procure any of these minerals, the course of the vein or bed is usually followed. The largest excavations are those of salt mines, some of which are several miles in extent. The deepest mine in Europe is the lead mine of Kuttenberg, in Bohemia, which is 3,000 feet in depth, but is now inaccessible. Some minerals are found upon the surface of the earth, mingled with its soil or sand, as is commonly the fact with gold and the precious stones. In this case, the mineral is procured by washing the sands.

### METALS.

*Gold* is the most precious of the metals, and is usually found in grains, or gold dust in a pure state. Nearly three-fourths of the gold of commerce is obtained by washing the sands of rivers and alluvions, and it is most abundant in countries near the equator. It is found in most parts of Europe, but nowhere in large quantities. The sands of the Danube, the Rhine, the Rhone, the Garonne, the Tagus, and many other rivers, contain small quantities. The chief mines of importance are at Kremnitz, in Austria, which produce more than all the rest of Europe. Mines have recently been discovered in the Ural Mountains, which are very productive. Africa furnishes large quantities of gold, which are washed down by the rivers. It is especially abundant on the Niger, in Western Africa, and on the coast of Zanguebar, and forms an important article of commerce. Japan also, and the East India Islands, particularly Sumatra, Borneo, and Celebes, produce gold for commerce. But Mexico and South America have produced it in far greater abundance than any other countries on the globe. At one period, a single mine furnished more of this valuable metal than all Europe. It is found along the base of the Andes, almost throughout their whole extent, sometimes embraced in veins of primary or secondary rocks. Brazil produces large quantities, chiefly from alluvial sands. It has also been found, in considerable abundance, throughout the whole region between the Alleghany Mountains and the alluvion of the coast. California, the most western state, has become celebrated for the large quantities of gold found in the valleys of the River Sacramento and its tributaries. Gold has recently been obtained in considerable abundance in that part of Australia lying to the eastward of the Blue Mountains, in the neighbourhood of the town of Bathhurst, and through the valleys of the Macquarie River. Further to the south, within the province of Port Victoria, gold has been found in still greater abundance.

*Platina* is a grayish metal, more rare, and, on some accounts, more valuable, than gold, and is usually found in connection with it. It occurs in several gold washings of South America, and has also been discovered in St. Domingo and in the Ural Mountains so abundantly, that it is now coined into money. Too little has been obtained to render it an important article of commerce.

*Silver*, as well as gold, is found in great abundance in Mexico and South America, particularly among the Andes. Mexico yields about 22,000 of dollars, and Peru, Chili, and Buenos Ayres, 10,000 annually. It is usually found in ores, but frequently pure, and in large masses. The first mines were discovered at Potosi by an Indian, who tore up a bush in ascending the mountain, and found a mass of silver beneath it. Huantaya, in Peru, and Guanaxuato, in Mexico, contain some of the most productive mines. The latter has a vein of silver ore 180 feet wide and 1,600 feet deep. The quantity of silver found in other parts of the world is comparatively insignificant. Schemitz and Kremnitz, in Hungary, are the principal mines in Europe. Those of Konigsberg, in Norway, have furnished very large masses of pure silver. It is also found in Saxony, and other parts of Europe, and at Kolhyvane, in Siberia. In the United States it has only been discovered in small quantities in lead ore.

*Iron* is the most useful of all the metals, and is the most extensively diffused. Its ores are found abundantly in all countries, and in every formation. It has been discovered more extensively in the northern than in the equatorial regions. The principal ores are the magnetic ore and ironstone of mountainous regions, and the bog-iron and iron-earth of alluvial districts. It is said to form two per cent. of the crust of the earth. Great Britain and France contain the most extensive mines in the world. Sweden has large mines of magnetic ore, which produce the best of bar iron. The mines of Danemark are particularly celebrated. At Gellivara, in Swedish Lapland, is a mountain of ore three miles in length. Norway, Russia, Spain, Germany, and Austria have extensive mines. The island of Elba contains one of the most ancient known, remarkable for the beautiful play of colours on the ore. In the United States there are numerous and inexhaustible beds of iron ore, particularly along the Alleghany or Apalachian Mountains.

*Copper* ranks next to iron in utility, and, though less abundant, occurs in many regions of the globe. It is often found in pure metallic masses, sometimes very large. England has some extensive mines of copper, particularly in Cornwall, and produces much more than all the rest of Europe. Considerable mines are also wrought in the middle and north of Europe, among the Ural Mountains, and in Siberia. Greenland, Iceland, Tartary, and Japan also furnish copper, as well as Barbary, Southern Africa, and the southern part of South America; those of Australia are now very productive. On Lake Superior, where it abounds, masses are found many tons in weight. Numerous copper mines are open in the United States and Canada.

*Zinc*, the metal which is combined with copper to form brass, is found in many countries in considerable abundance, and in several of the United States.

*Lead* is found more or less in all countries. It is said to be rare, however, in the Ural Mountains and in Peru, although other metals are abundant. It is found in the greatest quantities in Spain, and, next to Spain, in England and the lead hills of Scotland. The mines of the rest of Europe, chiefly found in Germany, France, &c., produce less than those of Spain alone. The United States contain several extensive beds of lead ore.

*Tin* is found in few countries. The principal mines of Europe are in Cornwall. They are very extensive and ancient, and have supplied most of the tin of commerce from the time of the Phœnicians. The German Mountains, and Gallicia, in Spain, also produce tin. It exists in Mexico and Chili, but not in any quantity, and has also been discovered in the United States. The Island of Banca, in the East Indies, contains large quantities of the ore; and it is found in India, Malacca, Sumatra, and Japan.

*Mercury*, or quicksilver, is also a valuable metal. The principal mines are those of Almaden, near Cordova, in Spain, Deuxponts, in Germany, Idria, in Austria, and in Peru. It is found in Mexico and New Granada. Small quantities, in the form of black and red sand, have been found in the United States.

*Cobalt*, which is chiefly used for giving a blue colour to glass and porcelain, is obtained almost entirely from Germany.

*Arsenic* is a metal found in most of the mining countries of Europe, but is chiefly procured from Germany and the countries on the Mediterranean Sea. Some of its ores form brilliant colours for the painter.

*Antimony* and *Bismuth* are brittle materials, which are combined with lead to form the metal for printing types. They are not common, and are obtained in commerce from the mines of Europe, particularly of Germany. There are several other metals, less common and important, of which the principal are *manganese*, *nickel*, *tungsten*, *molybdenum*, and *chromium*.

### PRECIOUS STONES.

The precious stones are among the most valuable of minerals. The finest, *Sapphires* and *Rubies*, come from Burmah, Madras, and Ceylon. The ruby has also been found in France, Bohemia, and Siberia, but is rare in other parts of the world. The finest *Emeralds* have been obtained from Peru and the neighbouring districts of New Grenada. The emerald is also found in Ceylon, Egypt, and Abyssinia. The *Beryl*, an inferior species of emerald, occurs in many parts of the United States.

The *Topaz* is chiefly obtained from Siberia, the Ural Mountains, Bohemia, Saxony, England, and Scotland. The finest is found in Brazil. The *Opal* is a beautiful stone, obtained chiefly from Hungary, and the *Garnet* from Bohemia.

*Jasper*, *Chalcedony*, and its varieties, *Cornelian*, *Onyx*, and *Agate*, are the most abundant of the stones termed precious, and are found more or less in almost every country. Egypt, the East Indies, Germany, and Scotland, appear to furnish the most beautiful. The *Amythyst* is also found in considerable abundance.

The *Diamond* is obtained almost exclusively from India. Brazil, and Borneo. It always occurs in alluvial beds, and is obtained by washing the earth. In Hindoostan, it is found from Cape Comorin to Bengal, but chiefly in the provinces of Golconda and Visiapore. The most valuable mine is on the Kristnah River. The diamonds of Brazil are chiefly found in the provinces of Minas Geraes, in beds of gravel and sand, from which they are washed by slaves. They have been found recently in the Ural Mountains.

### INFLAMMABLE MINERALS.

*Coal* is found more or less abundant in most secondary countries; but it is less common in primitive regions. *England* is remarkable for its coal mines. The principal are at Newcastle, in the county of Northumberland, and Whitehaven, Workington, and Carlisle in Cumberland, and Warrington in Lancashire. Coal is also abundant in some parts of Scotland, in France and Germany, and in China. It abounds in *South America*, even at a great height on the Andes. In *North America*, Cape Breton, and New Brunswick, and many parts of the United States, produce coal. One of the most extensive mines of bituminous coal in the United States is near *Richmond* (Virginia).

*Peat* or *Turf* is found in most alluvial countries, and is a valuable substitute for coal. It is almost the only fuel in some parts of Ireland and Holland. In the United States, it is found in New Jersey, and many other alluvial districts, and in some places is extensively used.

*Sulphur* is usually found in secondary formations, in connection with salt, gypsum, and marl, or calcareous clay. It occurs thus in Switzerland, Sicily, and Poland, and at most places where salt mines or salt springs exist. It is frequently deposited in considerable quantities from sulphureous springs, as at Ritchfield, in New York. In Siberia, it is collected from springs for the purposes of trade. Sulphur is most abundant in volcanic countries, and seems to be an important part of the fuel which supports their fires. Sicily and Iceland abound with it. It is always exhaled from the earth in the neighbourhood of volcanoes, especially in the craters of those which have become extinct, like the Solfatara of Naples. A large part of the sulphur of commerce, in Europe, is procured from dormant volcanoes. In Iceland, it is found in large masses near the surface of the soil. In the West India Islands of Guadaloupe, Martinique, and Montserrat, which appear to be volcanic, it is exhaled in some places from the earth.

*Bitumen* is an inflammable mineral, which occurs both solid and fluid. When purest, it is in the form of a whitish, transparent fluid, called *naphtha*. When impure, or altered by the air, it becomes dark-coloured and oily, and is called *petroleum*, or mineral oil. It is used in place of oil for lamps, and also for medical purposes. This fluid becomes by exposure as thick as tar, and is called *maltha;* and finally is converted into the hard, brittle substance called *asphaltum*. Baku, near the Caspian Sea, in latitude 42°, is most remarkable for its bituminous springs. For an extent of several miles, the soil abounds with naphtha and petroleum; so that wells dug in the sand are filled with it, and yield a large quantity daily. The vapour is constantly rising from the ground. At two or three inches below the surface, it will instantly take fire from a coal or lamp, and burn until it is extinguished. By inserting hollow canes into the ground, it is made to burn from the top, and is used by the inhabitants for fuel and light. The petroleum is also mingled with sand for fuel. This region is the chief sacred place of the Guebres, or worshippers of fire, who keep the flame continually burning.

*Petroleum* is also found in Modena, Parma, and Zante, and used for lamps. It occurs in many other parts of Europe. Near Rangoon, in Burmah, it is so abundant, that the springs are supposed to furnish 100,000 hogsheads annually. Springs of petroleum are found in the United States. *Maltha* is found in Barbadoes, and is called Barbadoes tar. *Asphaltum* is found floating on the waters of the Dead Sea, in Syria, in considerable quantities. In the Island of Trinidad, the celebrated Pitch Lake is covered with a crust of it, like ice. It is found in other places mingled with sand and iron, and is now used to form pavements and roofs for houses.

*Amber* is a resinous substance, of a beautiful colour, often made into ornaments. It occurs frequently in alluvial districts, and is obtained almost entirely from the alluvions on the shores of the Baltic, in Prussia and Poland.

### MINERAL SALTS.

*Salt* is a mineral of the first importance to man, and is found in great abundance in every part of the globe. The *ocean* is an inexhaustible mine of salt, from which it is continually formed, in hot countries, by the heat of the sun, and in cold countries by means of artificial heat. The Cape Verd Islands furnish large quantities, produced by the heat of the sun. Salt is also found in extensive beds, in secondary regions. In Cheshire there is a bed from 60 to 90 feet thick, which furnishes what we term Liverpool Salt. In Germany, Hungary, and Poland, there are numerous beds, particularly along the foot of the Carpathian Mountains, from the Black Sea to the Alps. The celebrated salt mines of Wielitzka, Cracow, are probably the most extensive in the world.

*Rock Salt* sometimes forms mountains, as at Cardona, near Montserrat, in Spain. In Moldavia, in Turkey, there is a mountain of salt, and in Hindoostan there is a chain of hills entirely composed of salt, which extends across the Indus through Cabul. Extensive plains, several miles in length, are sometimes found incrusted with salt. Many such occur in Northern Africa and the Sahara, Abyssinia, Persia, Siberia, and Tartary, which form important mines of salt. In South America, salt is found in great quantities in the desert of Atacáma. On the plains between the Andes and the Paraguay River, it is so abundant that there is scarcely a lake, stream, or well, which is not brackish. The Great Desert of North America is also incrusted with salt in many places; and its waters are generally brackish in the dry season. In many parts of the Western United States, there are spots of ground so impregnated with salt, that wild animals resort to them, and lick the surface. This has given them the name of *salt-licks.* A bed of rock salt has been found in the western part of Virginia.

*Brine-springs* are often found rising from beds of salt, so strongly impregnated with salt that it is obtained for use, by evaporating their waters. They are numerous in secondary regions, in all countries; England and the middle countries of Europe, as well as the secondary districts of the United States.

*Gypsum,* or Plaster of Paris, a mineral which is very valuable in improving land, is often found in connection with salt. It is procured in great abundance near Paris, from which it took its name. Considerable quantities were formerly brought to the United States from France, and from numerous quarries in Nova Scotia and New Brunswick. Within a few years, extensive quarries have been discovered in the United States. Other salts, such as *Glauber* and *Epsom Salts, Ammonia, Nitre,* and *Soda,* which are manufactured in large quantities for commerce, are also found as minerals.

*Ammonia,* or *Volatile Salt,* is found most frequently in the neighbourhood of volcanoes; as in Iceland, Naples, Sicily, and the Lipari Isles. Large quantities are obtained in Central Tartary; and in Persia and Egypt, it is found mixed with clay. It abounds in the oases of Egypt. *Glauber Salts* are found on the banks, and in the waters, of many salt lakes, in Siberia, Egypt, and other countries.

*Epsom Salts* are found in the springs of Epsom, in England, and some others, and in a cave in Illinois. *Borax,* a salt used in soldering metals, is found in lakes and caverns, in Tibet, Persia, Tartary, and Hungary. *Copperas* and *Alum* are manufactured from certain mineral beds, which are thence called alum or copperas beds. *Soda,* or *Natron,* is obtained in large quantities from the ashes of marine plants, chiefly in Spain, Portugal, and other countries on the Mediterranean, and is there called *Barilla.* But it is abundant, as a mineral, in the natron lakes of Egypt and Hungary; and it is found in India, Asia Minor, Siberia, and Russia. It is also found in several lakes in Mexico, and is very abundant in a lake in New Grenada. In La Plata, it occurs in considerable beds. *Nitre* occurs in great quantities in many of the plains of Spain, Hungary, and Russia. It abounds in South America, and in the deserts of Persia, Arabia, and Africa. It is also found in large quantities in the earth of calcareous caves, in India, Java, Naples, and the secondary region of the United States.

# CHAPTER VIII.

## MAP III.

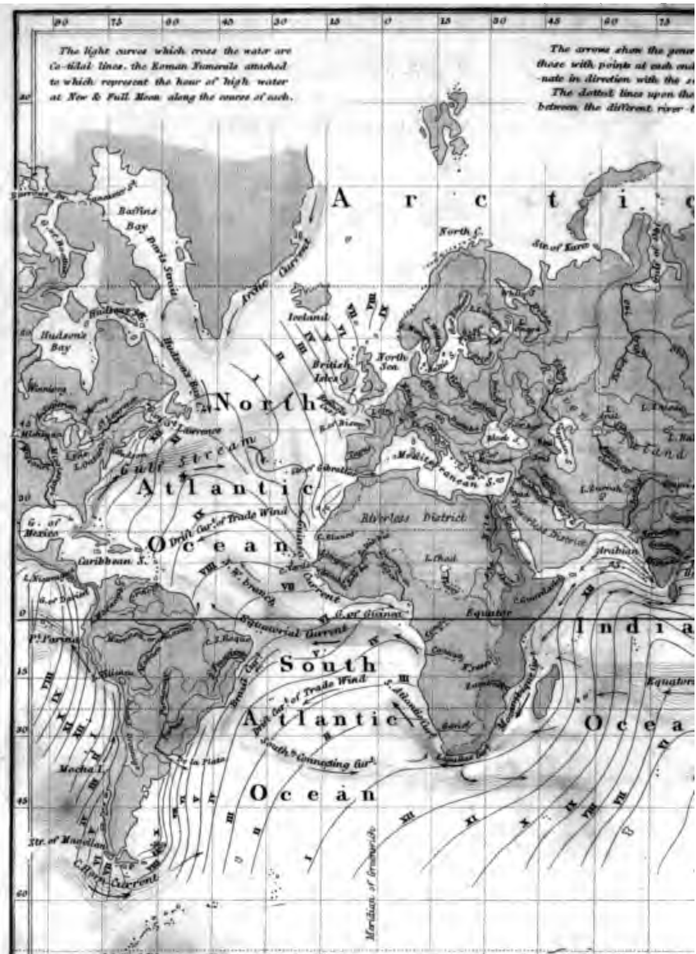
### THE OCEAN.

THAT vast body of water, termed the *Ocean*, which surrounds the dry land and penetrates its coast, covers nearly three-fourths of the surface of the globe. The bed of the ocean, like the surface of the land, is diversified by hills, mountains, valleys, and plains.

The chief chemical and physical peculiarities of its waters are their *colour*, *saltness*, *temperature*, *depth*, and *level*, with their *waves*, *tides*, and *currents*.

*The colour* of the sea is generally of a deep bluish green, which becomes clearer and brighter towards the coasts. The sea, however, is subject to remarkable changes of appearance, different shades—from the deepest indigo to green, and even a slaty grey—being produced by the shifting sunshine or passing clouds. The colour in some parts depends upon local causes; thus a purple tint is said to pervade the waters in the eastern part of the Mediterranean Sea. In the Gulf of Guinea the sea is white; and around the Maldives it is black. Between China and Japan it is yellowish; and west of the Canaries and Azores it is green. Off California, the Vermilion Sea is so named from the colour it often assumes. At the mouth of the La Plata the sea is of a reddish tinge; and of a similar colour in the Red Sea, whence its name. M. Ehrenberg asserts that the colour of the latter sea is owing to a species of *oscillaria*, a plant, intermediate between the animal and vegetable kingdom.

By repeatedly filtering fresh sea-water, this acute observer succeeded in procuring a fluid in which a large number of light-emitting animalcules were accumulated. It is not improbable, therefore, that a number of animalcules may give a reddish or whitish tint to an expanse of sea. Changes of colour are sometimes caused by the nature of the soil, or by the infusion of certain earthy substances in the water. Green



*The light curves which cross the water are Co-tidal lines, the Roman Numerals attached to which represent the hour of high water at New & Full Moon along the course of each.*

*The arrows show the gener… those with points at each end… -nate in direction with the s… The dotted lines upon the… between the different river-…*

*List of Rivers.—The figures in the 1st column express the length of each river in English miles, & those in the 2nd column the area of its basin, in English square miles.*

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Thames | 215 | 6160 | Neva | | | Lena | 2400 | 960.000 | Mackenzie | 2160 | |
| Severn | 240 | 8580 | Danube | 1620 | 310.000 | Amour | 2300 | 900.000 | St Lawrence | 2140 | |
| Tweed | 96 | 1870 | Dniester | 720 | | Hoang-ho | 2600 | 400.000 | Hudson | 328 | |
| Shannon | 224 | 6946 | Dnieper | 1200 | 200.000 | Yang-tsze | 3200 | 760.000 | Mississippi | 4000 | |
| Tagus | 510 | 34.000 | Don | 1100 | 205.000 | Ganges | 1680 | 420.000 | Grande del Norte | | |
| Loire | 570 | 48.000 | Volga | 2200 | 520.000 | Indus | 1700 | 400.000 | Oregon | 1200 | |
| Po | 450 | | Amoo, or Oxus | 1300 | | Euphrates | 1600 | 230.000 | Orinoco | 1200 | |
| Rhine | 760 | 70.000 | Sihon | | | Nile (probable) | 3200 | 500.000 | Amazon | 3800 | |
| Elbe | [illegible] | | Dwina (White S.) | 760 | | Senegal | 900 | [illegible] | S. Francisco | 1300 | |
| [illegible] | [illegible] | 76.000 | Obi | 2320 | 1300.000 | Quorra | 2200 | 580.000 | La Plata | 2250 | |
| | | | Enesei | 2900 | 1110.000 | Gariep | 1050 | 300.000 | Murray (Australia) | | |

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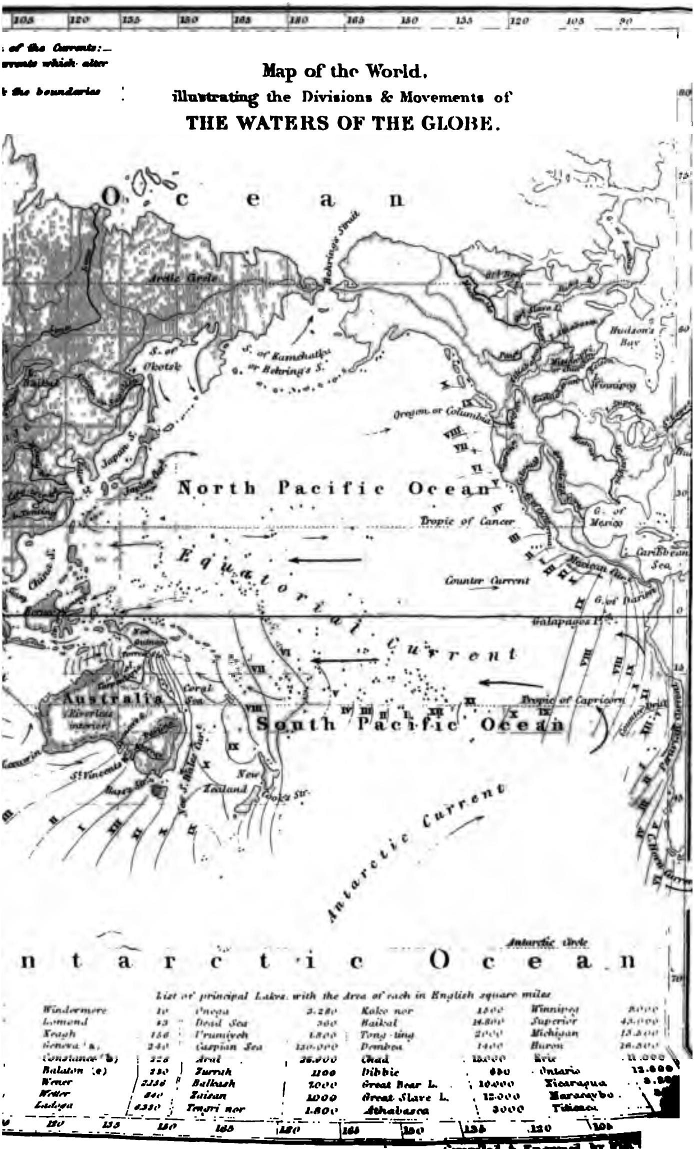
: of the Currents:—
rrents which alter

the boundaries

# Map of the World,
## illustrating the Divisions & Movements of
## THE WATERS OF THE GLOBE.



List of principal Lakes, with the Area of each in English square miles

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Windermere | 10 | Onega | 3.280 | Koko nor | 1500 | Winnipeg | 8000 |
| Lomond | 43 | Dead Sea | 360 | Baikal | 14.800 | Superior | 43.000 |
| Neagh | 156 | Urumiyeh | 1.800 | Tong-ting | 2000 | Michigan | 13.500 |
| Geneva (a) | 240 | Caspian Sea | 120.000 | Dembea | 1400 | Huron | 16.500 |
| Constance (b) | 228 | Aral | 26.000 | Chad | 13.000 | Erie | 11.000 |
| Balaton (c) | 230 | Zurrah | 1100 | Dibbie | 650 | Ontario | 13.000 |
| Wener | 2136 | Balkash | 7000 | Great Bear L. | 10.000 | Nicaragua | 3.0 |
| Wetter | 840 | Zaisan | 1000 | Great Slave L. | 12.000 | Maracaybo | |
| Ladoga | 6330 | Tengri nor | 1.800 | Athabasca | 3000 | Titicaca | |

Compiled & Engraved by W.

° 12.

and yellow shades frequently proceed from the existence of marine vegetation at or near the surface. The most beautiful and magnificent spectacle the sea exhibits is that brilliant dazzling light, termed *phosphoric light*, which may be seen at night in the wake of a vessel as she glides on through the billows, or at each lift of the oar, when the drops of sea-water fall like so many sparkling diamonds into a vast sheet of silvery light.

"I have seen the ocean," says Humboldt, "in the Tropics, luminous in the most opposite kinds of weather, but most strongly so before a storm, or in a sultry and hazy atmosphere with thick clouds. Heat and cold appear to exercise but little influence on this phenomenon, for on the Bank of Newfoundland the phosphorescence is frequently very brilliant in the severest winter. Occasionally, too, the sea will be highly luminous one night, and not at all so on the following, notwithstanding an apparent identity of external conditions."

The ocean is phosphorescent in all zones of the earth. The appearance presented in the tropical seas on a dark night is indescribably glorious, when shoals of dolphins are seen sporting around, and cutting the foaming wave in long and circling lines, gleaming with bright and sparkling light.

*The saltness* of the sea is one of its most distinctive characteristics. Besides muriate of soda (common salt) it contains several other substances, as muriatic and sulphuric acid, soda, magnesia, and sulphate of lime, varying in proportions in different places. It is these ingredients that give to sea-water that saltness and bitterness of taste which render it disagreeable and unfit for the use of man. In several places it is found to be less salt at the surface than at considerable depths, and, owing to the melting of large masses of ice, it is said to be less salt near the poles. The amount of saline matter is greatest at a distance from the shores, where the ocean is not diluted by the volumes of fresh water brought down by rivers. The degree of saltness in particular localities varies from temporary causes, such as the violent tropical rains which are collected in the great streams and returned again to the ocean free of saline particles. The bitterness which exists in sea-water is supposed to be given to it by vegetable and animal matter held there in a state of decomposition. The salt obtained by the evaporation of sea-water is preferred for the preservation of meat to that of springs.

All sea-waters do not hold in solution equal amounts of saline matter, the water, as tested in one locality, being in excess of that of another. If the water of the British channel be taken as unity, then

| | |
|---|---|
| The Baltic Sea equal | 0·19 |
| The Black Sea | 0·61 |
| The Irish Channel | 0·96 |
| The Mediterranean Sea | 1·11 |
| The Ocean at the Equator | 1·12 |
| North Atlantic | 1·16 |
| Sea of Marmora | 1·18 |
| South Atlantic | 1·20 |
| Dead Sea | 10·86 |

*Temperature.*—Water being a slow conductor of heat, absorbs and gives it out less freely than the atmosphere; its temperature, therefore, is more uniform, and is not subject to those rapid changes which take place in the atmosphere. Humboldt and others have shown that the temperature of the sea at the surface diminishes in a certain ratio as we recede from the equator towards the poles. In Baffin's Bay, the Mediterranean Sea, and the Tropical Seas the temperature of the sea diminishes with its depth, according to the observations of Phipps, Ross, Parry, Sabine, Saussure, Ellis, and Peron; but this diminution is not subject to any regular law. At the depth of 100 fathoms the difference is sometimes no more than 1°, and sometimes as great as 20°. Sometimes the coldness attains its maximum at 100 fathoms, and sometimes it increases to 400 and 500. Humboldt thinks that, on a mean, the change is about six times more rapid than in the atmosphere, or about 1° in 50 feet; but the facts are too anomalous to be easily brought under any general rule. It is remarkable that in the Arctic or Greenland Seas the temperature of the sea increases with its depth. This singular result was first obtained by Mr. Scoresby, and has been confirmed by the later observations of Franklin, Beechy, and Fisher.

The Rev. George Fisher, in H. M. ship *Dorothea*, in the year 1818, found the mean temperature of surface water during the summer, the sea being clear of ice, to be as follows:—

| | |
|---|---|
| Lat. 60° N. | 49° Fahr.* |
| 70° | 40° |
| 80° | 34° |

And similar results were obtained by Lieut. Beechy and Mr. Scoresby. The greatest difference found by Lieut. Parry was 6° at a depth of 246 fathoms; and the greatest obtained by Captain Sabine was 7½° at a depth of 680 fathoms. In March, 1843,* Sir James Ross found the temperature to be as follows:—

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* From a Paper by Dr. Marcett, in Phil. Trans. 1819.

| | |
|---|---|
| Lat. 50° s. | 37° |
| 60° | 31° |

Very little is known concerning the temperature of the ocean at great depths, but from the few experiments that have been made, it has been ascertained to decrease with the depth in temperate zones, and to increase with the depth in high latitudes.

The temperature of the ocean bears a very important relation to the theory of physical climate.

From numerous comparative observations of the temperature of the sea and that of the atmosphere the following results have been arrived at:—1. The temperature of the ocean is generally lower at mid-day than that of the atmosphere in the shade. 2. It is constantly higher at midnight. 3. In the morning and the evening the temperature of both is usually the same. 4. The mean temperature of the surface of the ocean far from land is greater than that of the atmosphere with which it is in contact. 5. The water over a sand-bank is colder than where it is deeper. This curious diminution of temperature might be of great use to the navigator in warning him of the existence of unseen danger, and thus prove his best sounding line.

The temperature of the ocean in low latitudes is considerably modified by the ice drifted by the polar currents from the Arctic and Antarctic Seas.

*Depth.*—No certain conclusions have been formed with respect to the depth of the ocean; all we know is that it varies from a few feet to several miles. In the North Sea, Lord Mulgrave sounded to the depth of 4,680 feet without reaching bottom. Off the coast of Greenland, Captain Scoresby sounded with a line of 7,200 feet with the same result; and 300 miles to the east of Cape Farewell, in Greenland, Captain Parry found no bottom with a line of 6,120 feet.

The greatest depth ever sounded was that by Captain Sir James Ross, in 15° 3′ s. lat. and 23° 14′ w. long., where a line of 27,600 feet (nearly 5¼ miles) was let down without finding bottom,—a depth equal in height to some of the most elevated peaks of the Himalaya.

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* 'Voyages to the South Sea.'

Frequently there is a general correspondence between the height of the land and the depth of the sea: where the coast is flat and low, the water is shallow for a considerable distance, slowly deepening; where the coast is abrupt, bold, and lofty, the sea that washes it is usually deep, and a ship may lie in calm weather almost close to the rocks.

Let us now see what is known of the vertical dimensions, or of the configuration of the basins of the ocean.

The basin of the oceans is depressed below the face of their waters, as the continents are elevated in the atmosphere above the same surface level. It may then be said, that we know not one-half of the reliefs of the solid crust of our globe, for more than two-thirds are concealed from our observation by the seas that cover them. It would, nevertheless, be of the highest interest for geology, as well as for the physics of the globe, to ascertain the forms, the depth, and the nature of the bottoms of the oceans. But though we have numerous soundings, executed in the neighbourhood of the shores, to meet the wants of navigation, we have only a very few in the interior and in the deepest parts of the oceans. These operations require a consumption of time and an amount of labour which will always render them rare. Recourse has been had to hypotheses, while waiting for positive information on the subject. In the neighbourhood of the continents the seas are often shallow, and their bottom seems to be only the continuation, by gentle slopes, of the relief of the continents which border them. Thus the Baltic Sea has a depth of only 120 feet between the coasts of Germany and those of Sweden, scarcely a twentieth part of that of Lago Maggiore, in the Italian Alps; farther north it becomes deeper. The Adriatic, between Venice and Trieste, has a depth of only 130 feet. In these two cases we see that the bed is only the continuation of the gentle inclination of the plains of Northern Germany and Friuli. It is the same with the Northern Sea, and with those which wash the British islands. Here is found a submarine plateau, which serves as a common basis for the coasts of France and the British islands; nowhere does it sink lower than 600 feet, and frequently it rises much higher. Between France and England the greatest depth does not exceed 300 feet; but at the edge of the plateau, south-west of Ireland, for example, the depth suddenly sinks to more than 2,000 feet; we may say that here the basin of the Atlantic really begins.*

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* Ascertained by Captain Vidal's soundings in the Atlantic, 1841.

The seas in the south of Europe are distinguished from the preceding by their much greater depths. The basin of the Mediterranean may be called a basin broken through and fallen in, resembling on a small scale what the Pacific Ocean is on a large one. All the short and abrupt slopes of the land surrounding it fall rapidly towards the interior. The western basin in particular seems to be very deep; it is isolated from the Atlantic by a submarine ridge or neck, which in the narrowest part of the Strait of Gibraltar is not more than 1,000 feet below the surface; but a little farther towards the east the depth falls suddenly to 3,000 feet; and at the south of the coast of Spain, and of the Sierra Nevada, a depth of nearly 6,000 feet has been ascertained by Captain Smith. Captain Berard indicates still greater depths on the coast of Algeria. If we may believe Marsigli, and if he has not made some mistake in the statement, there has been found in the prolongation of the Pyrenees the enormous depth of 9,000 feet. Not far from Cape Asinaca, on the north-west of Sardinia, the plummet has been sunk, without touching bottom, at a depth of nearly 5,000 feet.

Between Sicily and the coast of Africa, at Cape Bon, a second neck, from 50 to 500 feet in depth, separates the western from the eastern basin of the Mediterranean. The latter seems to be less deep than the former; nevertheless, depths of from 2,000 to 3,000 feet have been determined in the neighbourhood of the Ionian Islands and the southern coast of Asia Minor.

The Black Sea seems to partake of the character of a sunk basin. The Russian maps give it more than 3,000 feet south of the Crimea, and 2,500 on the coast of Abkhasie. The Caspian Sea, placed on the limits of the northern plains and of the table-land of Persia, is composed of two basins. The northern part, as far as the Caucasus, is shallow; it is the continuation of the low plains of the Volga and of the Oural. This limit passed, the depth rapidly increases towards the basis of the high chain of the Demavend. Thus, in the European seas the depth increases with the elevation of the surrounding lands.

The line of the islands and the peninsulas forming along the eastern coast of Asia the numerous locked seas which we have already named, seem to indicate the ancient border of a continent. Within this line these seas have only an inconsiderable depth. The seas which bathe the archipelago of the Sund islands and of Southern China scarcely anywhere reach the depth of 300 feet. Farther north we find scarcely 400 or 500 feet, even at a distance of more than 100 miles from the coasts. The deeps of the ocean begin only outside of the line of the islands.

Since Dampier, it has often been said that the sea is always deep at the foot of high and steep shores, and shallow at the edge of low coasts.

The facts which have just been cited prove that this observation, correct in many cases, has only a relative value, and does not hold good universally. Those shallow seas of Eastern Asia are edged in great part by very high lands. The massive point of the south of Africa ends with abrupt coasts, and yet it is necessary to go out more than 100 miles before finding 600 feet of water. According to this rule we should expect to find no greater depth of sea than at the western foot of the lofty Andes, the declivities of which sweep down so suddenly into the Pacific Ocean; and nevertheless, under the parallel of Lima, this ocean has only 600 feet more than 40 miles from the coast. On the other hand, the low plains of the Landes of Bordeaux, on the coast of France, which lie along the Gulf of Biscay, look out upon a sea, the bottom of which, at a short distance, sinks already lower than 1,000 feet. In Central America, according to Humboldt, the Gulf of Mexico, 100 miles north of Yucatan, has a depth of only 600 feet; it is the submarine continuation of the plains of Mississippi. Beyond the line of the Antilles, on the contrary, in the volcanic basin of the Caribbean Sea, Captain Sabine records a temperature taken at 6,000 feet below the surface.

With regard to the depths of the open sea, they are but still little known; we have, however, a few in the Atlantic Ocean. Captain C. H. Davis, U. S. N., sunk the lead 7,800 feet in the neighbourhood of the coasts of the United States, about 250 miles south of Nantucket. It is the greatest that has been reached in the middle latitudes of the Atlantic. Captains Scoresby and Parry have found the bed of the Polar Seas very deep, but variable. Scoresby did not touch the bottom at 76° north latitude, with a sounding line of 7,200 feet in length. Captain Ross has exceeded 6,000 feet in Baffin's Bay. But the most astonishing depths that have been ascertained are found in the Southern Atlantic. Captain Sir James Ross, as we have already stated, has found 16,000 feet west of Cape of Good Hope, and he has sounded with the plummet 27,600 feet, without touching bottom, west of St. Helena. The first of these measures is equal to the height of Mont

Blanc, the second to that of Dhawalagiri. Thus the greatest known sea depth, added to the elevation of highest mountain of the globe, gives us about 55,600 feet for the thickness of the layer of our globe, upon which our investigations have given some information.

Dr. Young, relying upon deductions drawn chiefly from the theory of the tides, thought himself justified in assigning about 15,000 feet to the Atlantic, and about 20,000 feet to the Pacific. D'Aubuisson believes them not to exceed from 9,000 to 12,000 feet. Now we see that the measurements of Ross leave these estimates far behind. Laplace, guided by theoretical considerations with regard to the general form of the globe, admitted that the mean depth of the seas is a quantity of the same order with the mean elevation of the continents, which, he says, does not surpass 3,000 feet. But the beautiful researches of Humboldt have proved that this estimate of the mean relief of the continents is far too high. He has sought to determine its true value, and has found as the most probable result the following numbers for the different continents :—

| | Mean Elevation. |
|---|---|
| Europe - - - - | 671 feet. |
| Asia - - - - - | 1,151 „ |
| North America - - | 748 „ |
| South America - - | 1,132 „ |

He consequently places the mean elevation of the continental lands at 1,008 feet above the level of the ocean.

Now this number is evidently too low to express the mean depth of the oceans.

Professor B. Pierce has made a calculation, which gives the following result. Taking as points of departure for Africa, the table-lands of Southern Africa, at the foot of Lupata, and estimating their height at 5,000 feet; and for America, the table-lands of Bolivia, estimated at 12,000, the planes which pass through the respective coasts of these continents intersect each other at a distance of nearly a thousand miles from the coast of America; that is, a third of the way across the Atlantic, and 7,600 feet below the surface of the oceans. If the points of departure were taken at the summit of the Lupata at 11,000 feet, and of the Andes at 24,000, the depth would be about 15,000 feet, which perhaps is not far from the mean depth of this part of the great oceanic valley. But we see that other causes depress the level in some parts to depths twice as great. The basins are not, therefore, mere continuations of the general relief of the continents, and this is otherwise shown by their conformation ; but we must wait for positive information for the complete solution of the question.

What the measurements above indicated have settled may be thus summed up :—

The seas in the neighbourhood of the continents are ordinarily of but little depth, and seem to indicate a continuation of the relief of the continents. But at a certain distance from the shores the sounding gives suddenly great depths, and this abrupt transition seems to indicate the submarine border of the proper basin of the oceans.

Certain interior seas, like the Mediterranean and Caribbean, are deeper than would be expected from their proximity to the lands, and seem to be sunken basins, the form of which is connected with the volcanic phenomena that are often displayed over their whole extent, but chiefly on their margins, that is, on the principal line of fractures. The interior of the basin of the oceans is unequal, generally deeper than towards the borders. The greatest observed depth is in the Southern Atlantic, nearly under the parallel of the highest peaks of America, and equal to the elevation of the highest mountain of the globe.

The mean depth of the basin of the oceans seems to be more considerable than the mean elevation of the continents above their surface, and appears to increase with the relief of the neighbouring continents.

*Level.*—The ocean is presumed to have everywhere an uniform surface, which is called the *level of the sea ;* some of its branches form an exception to this rule, their waters being sometimes raised by prevailing winds and currents. Thus it is asserted that the surface of the Zuyder Zee is considerably higher than that of the German Ocean, and that the Red Sea at certain seasons is more elevated than the Mediterranean. In the Baltic and Black Seas the level changes with the seasons, being highest in spring, when the rivers, flowing into these recipients, discharge the greatest quantity of water. But the unconfined ocean has no difference of level, it is unchangeable.

## I. *Waves.*

Waves are produced by any cause which disturbs the equilibrium of the particles of a fluid. The ocean exhibits two kinds of waves ; one called the *sea-wave*, which is produced by the friction of the wind; the other, termed the *tide-wave*, is raised by the attractive influences of the sun and moon. The height of the former in open seas depends upon the force of the wind, and the angle at which it impinges upon the surface of the water, but in confined places the heights and forms of waves are effected by the resistance of the sea-bottom and the character of the shores. The elevation of the tide-wave depends upon the relative positions of the sun and moon with respect to the earth.

When a gentle wind blows in a direction parallel to the surface of the sea ripples appear; and if the action be continued long the ripples will increase and become waves. When the wind exerts an irregular pressure obliquely upon the water some of the particles are forced above the general level, and afford a surface upon which the wind can act directly. The equilibrium now being destroyed, if the wind continues to blow and increase in velocity, the mightiest waves are produced.

It has been ascertained that the agitation of the water extends but a little way below the surface, except during long-continued stormy weather. A wave elevates itself to a certain height, and then gradually sinks until it is as much below the medium level of the sea as it was before above it. Therefore in estimating the elevation of a wave, the height from the trough to the crest is taken.

The waves of the sea are partial displacements at the surface, which do not extend to considerable depths, and are therefore totally different in character from the great waves of translation, in which the motion of displacement of the particles is uniform to the greatest depth. The displacement of the particles of the fluid in the waves of the sea is greatest at the surface, and diminishes rapidly. There are generally on the surface of the sea, several coexistent classes of oscillations of varying direction and magnitude, which by their union give the surface an appearance of irregularity which does not exist in nature. When waves of the sea approach a shore, or come into shallow water, they become waves of translation, and, obeying certain laws, always break when the depth of the water is not greater than their height above the level.

The largest waves known are those which occur off Cape Horn, and those produced by a north-west gale off the Cape of Good Hope, some of which reach to the astonishing height of 30 and 40 feet.

"The sea-shore after a storm presents a scene of infinite grandeur. It exhibits the expenditure of gigantic force, which impresses the mind with the presence of elemental power as sublime as the waterfall, or the thunder. Long before the waves reach the shore they may be said to feel the bottom as the water becomes shallower, for they increase in height but diminish in length. Finally, the wave becomes higher, more pointed, assumes a form of unstable equilibrium, totters, becomes crested with foam, breaks with great violence, and continuing to break is gradually lessened in bulk till it ends in a fringed margin."*

Besides the agitation by the waves the ocean is subject to an undulation, called the *ground-swell*, which continues to heave the bosom of the mighty deep long after it has been roused by the distant storm or the hurricane.

### II. *Tides.*

The most remarkable of the motions to which the ocean is subject, is that alternate rise and fall of its surface, known by the name of the tides, which usually take place twice in 24 hours 50 minutes. 28 seconds, mean solar time. They are occasioned by the attractive forces of the sun and moon, particularly the latter, by which they are mainly governed. The particles of water moving freely among themselves with little force of cohesion readily yield to any impulse. The moon, by attracting the waters, diminishes their gravity, so that they have a tendency to leave the earth, and move towards the attractive force, and thus they are raised or drawn up under the moon.

On the contrary, the moon attracts the centre of the earth more powerfully than she attracts the particles of water in the hemisphere opposite to her; the earth is thus drawn away from the water, and an elevation of the ocean is produced on the side of the earth which is opposite to the moon, as well as under her.

This elevation being caused consecutively at different places, assumes the form of a great wave, which follows the motions of the moon as fast as the rotation of the earth, the inertia of the waters, and the obstructions of the land will permit; a similar wave, but much smaller, is caused by the attraction of the sun. When the action of the sun is combined with that of the moon, which is the case at the time the moon is in conjunction and opposition, or at new and full moon, the solar and lunar waves mutually reinforce each other, and unite in producing the highest or *spring tides.* When the moon is in quadrature, these two waves tend to neutralize each other, and tides of less elevation, called *neap tides,* take place; the former of these is the joint result or sum of the two waves, the latter their difference.

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* John Scott Russell on 'The Theory of Waves.'

As the sun and moon are perpetually changing their positions with respect to each other and to the earth, their attractive influences upon the mass of waters must also be continually varying; hence the differences in both the heights and times of high water at any particular place.

In every sea-port the actual time of high water on the day when the moon passes the meridian at the same time as the sun, or the interval between the time of transit of the moon and the time of high water on the days of full and change, is called the "Establishment of the port," because, this being established, the time of high water on any other day may in most cases be known.*

Suppose, then, we find upon the surface of the earth and sea a number of points at which the "Establishment" (reduced to Greenwich time) is the same, and draw a line through these points, this line will indicate the summit of a great tide wave at that instant, just as if we had suddenly stopped the wave in its progress, and traced upon the map a line representing its summit: again, if we draw a line through all the points at which the "Establishment" is an hour later, a new position of the summit will be obtained, and the wave will have travelled in one hour from the position indicated by the first line to that indicated by the second.

These are called "Co-tidal lines;" † they are laid down on Map 3, and on the Map of the British Isles, No. 8.

The only tide waves with which we are well acquainted are those of the Indian and Atlantic Oceans. The cradle of the tides is supposed to be the Pacific Ocean to the south of Australia, from which a wave advances towards the Indian Ocean, and, proceeding northward, enters the Bay of Bengal and the Persian Gulf, causing the hour of high water to be successively later at the ports on both sides of the peninsula of Hindoostan. A single wave seems to extend from the entrance to the Red Sea along the eastern coast of Africa to the Cape of Good Hope. It then enters the Atlantic, and stretching from the western shores of Africa to the eastern shores of South America, brings high water successively later at the different ports on these shores, reaching Cape Blanco, in Africa, and Newfoundland, in North America, at the same instant, twelve hours after it has entered the bed of the Atlantic. In fifteen hours after it has left the Cape, it is at the mouth of the English Channel, and stretches along the western coast of Ireland. It then divides into three branches: one principal branch flows up the channel, passing through the Strait of Dover, and in eight hours (as indicated upon the Map of the British Isles) is off the mouth of the Thames.

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* A Table of 'Establishments' for the ports of Great Britain and Ireland, is given in the Nautical Almanac, pages 580 to 583, and the rise of *Spring* and *Neap* tides is indicated on the Admiralty Charts.

† They were first indicated on a chart of the world by Sir John Lubbock, in *the Phil. Trans.* for 1831.

A small branch advances up St. George's Channel, producing the enormous stream tide of the Bristol Channel; but the second principal branch moves with great rapidity along the western shores of Ireland and Scotland, flows round the Orkneys, thence proceeds slowly down the North Sea and German Ocean, and meets the first branch in twenty hours from the time that it was at the entrance of the channel. This great wave brings high water successively to the harbours and rivers it passes along the coasts, at periods of time ranging over the twenty-four hours. Along the shores of South America, from Rio Janeiro to the Falkland Isles, a wave advances from east to west, bringing high tide later in going southward, as if the wave came from the north. On the western coast of South America the tide travels from north to south between the Gulf of Panama and the Strait of Magellan; and on the same side of North America it travels from the Gulf of Panama, on the south, northward to Queen Charlotte's Sound. In the Pacific Ocean, the tide wave proceeds in the direction from east to west, but the heights of the tides are small, not exceeding two feet in the South Sea Islands.

Peculiarities in tides occur in different places, arising from the interference of waves; but of all the irregularities to which the tides are subject, those are the greatest which are occasioned by the obstacles offered by the land to the ebb and flow of the waters. The height to which the tides rise is much greater in narrow channels than in the open sea. They are greatly delayed, altered both in degree and in direction, and in many places accumulated, by the nature of the shores, bays, gulfs, and the projections of islands and continents, so that they rise to heights far exceeding that which is attained in the open ocean. On the coasts of the islands of the Pacific Ocean there are regular tides of only one or two feet in elevation; but on the eastern shores of Asia and the western shores of Europe the tides are very strong and have many variations. The sea is so pent up in the British Channel that the tides sometimes rise to the surprising height of fifty feet at St. Malo, in Bretagne, on the coast of France. In the Bay of Fundy, on the north-east of America, there are extraordinarily high tides; a vast wave is seen for thirty miles off, approaching with a prodigious noise, sometimes rising in the bay to the height of 100 and even 120 feet: on some occasions the rapidity of the waters is so great as to overtake animals feeding on the shores.

A tidal bore is formed when the water is so shallow at low water that the first waves of flood tide move with a velocity so much less than that due to the succeeding part of the tidal wave, as to be overtaken by the subsequent waves, wherever the tide rises so rapidly, and the water on the shore or in the river is so shallow that the height of the first wave of the tide is greater than the depth of the fluid at that place. Hence in deep water vessels are safe from the waves of rivers, which injure those on the shore. The identity of the tide wave, and of the great wave of translation, show the nature of certain variations in the establishment of ports situated on tidal rivers. Any change in the depth of the rivers produces a corresponding change on the interval between the moon's transit and the high water immediately succeeding. It appears from observations, that the mean time of high water has been rendered thirty-seven minutes earlier than formerly by deepening a portion of about twelve miles in the channel of a tidal river, so that a tide wave which formerly travelled at the rate of ten miles an hour, now travels at the rate of nearly fifteen miles an hour. It also appears that a large wave, or a wave of high water of spring tides, travels faster than a wave of high water of neap tides, showing that there is a variation on the establishment, or on the interval between the moon's transit and the succeeding high water, due to the depth of the fluid at high water, and which should, of course, enter as an element into the calculation of tide tables for an inland port derived from those of a port on the sea-shore. The variation of the interval will vary with the square root of mean depth of the channel at high water.

*Progress of the Tide-wave.*—In order that the phenomena of the tides at different places may be readily compared together, charts of co-tidal lines (see Map 3) have been constructed, on which the time of high water at certain places may be readily seen. The explanation of such a chart is this: suppose the sun and moon to be on the same meridian, which is the case at new or full moon, spring-tide will then be produced. Now let us suppose that the coincidence of the actions of these luminaries in conjunction or opposition takes place at twelve o'clock (say on Monday), and at that instant the waters of the Pacific to the east of Van Diemen's Land (say about the meridian of 155° E. long.), are sweeping under the moon, an initial impulse will then be communicated to the mass of waters, and a wave raised, which, following the motion of the moon, will proceed westward, and bring high water on the coast of Van Diemen's Land at midnight. The wave now travels northward and westward, and is off the peninsula of Hindoostan at noon on Tuesday, and at one o'clock is off the Cape of Good Hope. It then enters the Atlantic, and, moving continuously northward, brings high water successively to all the ports on the western shores of Africa and eastern shores of America, reaching Cape Blanco, on the west of Africa, and Newfoundland, on the American continent, at midnight of Tuesday. Then, turning eastward, it reaches the coast of France and the mouth of the channel about four o'clock the next morning. Proceeding along the western shores of Ireland and Scotland, it passes round the north of Scotland, bringing high water to Aberdeen at noon on Wednesday. From this point it proceeds slowly, taking twelve hours to reach the mouth of the Thames, which it does at midnight on Wednesday. The progress of this wave round the British Island, as well as the rise of tide in feet, is indicated upon the Map No. 8.

We subjoin remarks from Mr. Airy's Treatise in reference to the co-tidal lines of the globe, as they have a special relation to the question of depth and its effects.

"In all places where the circumstances of depth, &c., vary much in a small extent of sea, we may consider the alteration in the tides through that extent as following simply the laws of waves on which no force is acting (because the length of the column of water on which the sun or moon acts is too small to allow their attraction sensibly to modify their pressures). Suppose now that in the neighbourhood of any particular coast, the bottom shelves gradually from deep sea to one comparatively shallow. This would be attended, theoretically, with two consequences. The first is, that the wave would travel more slowly, and therefore the separation of the co-tidal lines corresponding to successive hours would be less, or the co-tidal lines would appear to be crowded together on the map. The second is, that the magnitude of the tides would be much increased. And these circumstances are found in places where the change in the depth was not known from observation; for the usual limit of sounding is 200 fathoms, which is probably a small quantity compared with the depth of the ocean. We may then expect that, where the co-tidal lines approach closely, the magnitude of the tides will be increased. Now this does occur. A well-marked instance is the Bay of St. George, in South America, in which a close approximation of co-tidal lines is accompanied with large tides. It is possible here that the tides may be still further increased by the converging form of the waves.

"Another curious effect of the same cause is the distortion of the lines produced by islands, surrounded by shoals, in the ocean. The shoals prevent the tide-wave from advancing rapidly, and the co-tidal line is therefore thrown back; but, conceiving the ridge of the wave to be thus bent, it is easy to imagine that after passing the island the two lateral parts of the wave will bend round it till they unite, and will then form a straight front nearly as before coming to the island. The successive co-tidal lines will have forms corresponding to the forms of the ridge of this wave at successive times. Of this there are several instances apparently beyond doubt. Thus the 1 o'clock line is thrown back by the Azores; the 11 o'clock line is bent by the Bermudas, and lateral branches nearly meet; the 10 o'clock line, after having been interrupted, just meets behind New Zealand. A similar effect of the same cause is the universal dragging of the wave along the shore."

### III. *Currents.*

*Causes of Currents.*—The third movement exhibited in the "mighty deep" is that produced by vast marine streams termed *currents*, which keep up a perpetual circulation of the ocean waters, transferring them from one hemisphere to another—from the Pacific to the Atlantic, and to the Pacific again—and from the neighbourhood of the icy poles, to the warm regions of the torrid zone. The causes which disturb the equilibrium of the ocean, producing in it streams of various extent, magnitude, and velocity, are, the influence of tides and of winds—the expansion and contraction of water by heat and by cold—the evaporating power of the sun—and the revolution of the earth about its axis.

The rise and fall of the tides frequently occasion an alternate flowing of currents in opposite directions, which is very striking in estuaries and channels between islands, such as in the Orkney and Shetland Islands. Long-continued winds blowing in the same direction invariably produce currents; this has been observed along the west coast of England and in the Channel, when a strong south-west or north-west wind has prevailed for any length of time. A north-west wind of any lengthened duration causes the Baltic to rise two feet and upwards above its ordinary level.

Another cause of oceanic currents is the evaporation by solar heat: large quantities of water raised from one tract of the ocean are carried to some other, where the vapour is condensed and falls in the form of rain; this, in flowing back to restore equilibrium, causes sensible currents.

The way in which heat and cold affect the watery particles of the ocean is, perhaps, the principal cause to which currents are due. Certain portions becoming heated, rise by reason of their buoyancy above the general surface, and are replaced by surrounding colder and heavier fluid flowing in beneath them; the heated portions being raised above the general surface, spread themselves with a tendency to restore equilibrium, and flow along the surface from the equator towards the poles. The particles of superficial water continue to move in the direction of the cold regions, until their temperature becomes so reduced that condensation takes place; their specific gravity now being increased, they fall to the bottom, and move along the inferior parts of the ocean towards the warmer regions, again to be subjected to the same heating influences as before. Thus within certain latitudes *surface currents* are established from the equator towards the poles, and *submarine currents* from the poles towards the equator.

In high latitudes, also, whenever the temperature of the surface is lowered, a circulation of ascending and descending currents is produced, by which the lower parts of the sea are made to consist of colder and heavier fluid than the corresponding depths of the ocean between the tropics.

In consequence of some one or all of these forces, the waters of the ocean are put in motion, and two great currents perpetually set from each pole towards the equator. The existence of these is proved by masses of ice floating from the frigid to the temperate regions. Icebergs drifted from the North Pole have been met with at the Azores, and from the South Pole they have come even to the Cape of Good Hope. When these currents set out from the poles, they move directly towards the equator, but are gradually deflected in moving from regions where the rotatory motion of the earth's surface is very slight when compared with that at the equator, where it revolves at the rate of upwards of 1,000 miles an hour; here the waters cannot immediately acquire the rapid motion with which the solid parts of the earth revolve; hence the whole surface of the ocean, for about 30 degrees on each side of the equator, is left behind; or in other words, it has a general movement from east to west, which produces all the effect of a current in that direction, and this effect is further increased by the constant blowing of the trade winds.

This great oceanic current originates in the immense expanse of the Antarctic Ocean (see Map): first moving in a north-easterly direction, it reaches the American shore; a small branch rounds Cape Horn, but the great stream flows along the American coast until it arrives off the shores of Peru; it then turns towards the west, and in a belt 3,500 miles broad, called the great Equatorial Current, commences within the limits of the tropics its grand tour of the Pacific Ocean. On reaching the south-eastern shores of Asia, the Indian Archipelago, and Australia, it is broken into numerous smaller streams; but a large volume of water forces its way through the islands, and joins the great equatorial current of the Indian Ocean. As this stream approaches the eastern shores of Africa, it is again divided by the island of Madagascar; one branch flows round the north of that island, sweeps through the Mozambique channel, where, having dashed against the shores of Africa, it is joined by the other branch; then doubling the Cape, outside of the Agulhas Bank, it enters the bed of the Atlantic Ocean. Proceeding northward along the western shores of Africa, it mingles with the great Atlantic equatorial current, which divides into two great branches off Cape St. Roque, in Brazil. One sets along the coast of South America, and before reaching the estuary of the La Plata it is deflected towards the east, and under the name of the South Connecting Current makes the circuit of the South Atlantic Ocean, entering the Indian Ocean 200 miles to the south of the Cape of Good Hope.

The principal branch of the equatorial current of the Atlantic rushes along the coasts of Brazil, Guiana, and Columbia, into the Caribbean Sea; it enters the Gulf of Mexico between the western extremity of the island of Cuba and the peninsula of Yucatan, here it follows the bendings of the Mexican coast from Vera Cruz to the Rio del Norte, and thence to the mouths of the Mississippi. The temperature of the Gulf of Mexico is at least 7° higher than that of the Atlantic under the same parallel. From this reservoir or caùldron of warm water, the most powerful current known—the *Gulf Stream*—pours forth at the rate of five miles an hour through the Strait of Florida into the Atlantic Ocean. Flowing in a north-easterly direction, it sweeps along the whole coast of America, and skirts the bank of Newfoundland, where it still retains a temperature of 8° above that of the surrounding sea; then bending to the east, it crosses the Atlantic, and after flowing nearly 3,000 geographical miles, reaches the Azores in about 78 days. It then turns towards the Strait of Gibraltar, the Isle of Madeira, and the group of the Canaries, till, on reaching the parallel of Cape Blanco, it completes the round by mingling with the grand westerly current of the tropics, about the parallel of 21° N. lat. Thus we see that the waters of the Atlantic between the parallels of 11° and 43° are kept in a perpetual whirlpool, by which a single particle of water describes a great circuit of about 3,800 leagues in the space of two years and ten months. Humboldt says, that "we can estimate from our present knowledge of the swiftness of currents, that this circuit of 3,800 leagues is not terminated in less than two years and ten months.

"A boat which may be supposed to receive no impulse from the winds would require thirteen months, from the Canary Islands, to reach the coast of Caraccas; ten months to make the tour of the Gulf of Mexico, and reach Tortoise shoals, opposite the port of the Havannah; while forty or fifty days might be sufficient to carry it from the Strait of Florida to the Bank of Newfoundland. It would be difficult to fix the rapidity of the retrograde current from this bank to the coasts of Africa; estimating the mean velocity of the waters at seven or eight miles in twenty-four hours, we find ten or eleven months for this last distance." This current may always be distinguished by its waters being more salt, and of a deeper blue, than the surrounding sea; its temperature also is greater, and there are large quantities of sea-weed floating upon its surface. In the centre of this great oceanic stream there is a mass of nearly stagnant water, covered by the weed called *Sargasso*, which the current floats in abundance from the Gulf of Mexico.

"This is the situation of the Sargasso Sea, or that great sea of weed, or bank of fucus, which made so lively an impression on the imagination of Columbus, and which Oviedo calls sea-weed meadows,—'praderias de yerva.' These evergreen masses of *Fucus natans* (one of the most widely distributed of the social sea plants), driven gently to and fro by mild and warm breezes, are the habitation of a countless number of small marine animals."*

In the 15th century the bodies of two men of unknown race were cast ashore upon the western coasts of the Azores, and, subsequently, pieces of bamboo were found on the coast of the small island of Porto Santo: these facts are said to have suggested to Columbus the idea of land beyond the western ocean, and led to the discovery of America. Fruit trees, plants, and seeds belonging to the torrid zone of America are wafted every year to the western shores of Ireland and Norway. Some years since, the timbers of a vessel that was wrecked near Jamaica were found on the shores of Scotland.

The heat of this great body of water, which is kept up by constant and rapid supplies of warm water from the south, has an excess of 5° above the mean temperature of the Bay of Biscay when it reaches that sea: this warmth must tend greatly to moderate the cold of winter in the countries of Western Europe, and there can be little doubt that the climate of America is materially affected by the same cause.

The narrow currents or true oceanic rivers, some of which carry warm water into higher, and others cold water into lower latitudes, may all be classed into *constant*, *periodical*, *variable*, *counter*, and *drift* currents. Constant currents are produced by the combined influence of winds, differences of temperature in the waters of the ocean, the rotation of the earth, and variations of atmospheric pressure. Periodical currents are due to the action of tides, land and sea breezes, and monsoons. Variable currents are occasioned by tides, winds, and the melting of ice in the polar regions. Counter current is a name given to a stream that flows alongside, and in opposite directions to, other currents. Drift currents are the effect of permanent and prevailing winds upon the surface of the sea, impelling the water to leeward, until, meeting with land or sand-banks, its progress is stopped, and an accumulation of water takes place: this gives rise to what is called a *stream current*, which carries off the collected waters to restore the equilibrium of the surface of the ocean. Each of the great oceans has its system of currents: the position and direction of the principal of these will be found indicated upon the map. They perform an important part in the economy of nature, causing an exchange of the waters of the different regions of the globe, thereby tempering the climate and moderating alike an excess of heat or cold.

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* Humboldt's 'Cosmos.'

The subject is one of interesting inquiry and of the greatest importance in navigation. The mode of ascertaining the direction of currents is by "Track Bottles," which are thrown overboard in the ocean. Upon comparing the place where they have been cast in with that in which they have been taken up, the direction of the current becomes known. "Bottles thrown overboard, with a label inside containing the date and latitude and longitude of the spot where cast into the sea, afford ready means of detecting the current if picked up afterwards, and ships would do well frequently to expend a few empty bottles in this way. In the event of meeting any such drifting at sea, they should be picked up, their contents copied, and the date and position of the spot added to the label and carefully re-sealed; they should then be returned to the ocean, and a copy of the label forwarded to the hydrographer."*

### IV. *General Remarks on the Influence and Aspect of the Ocean.*

The ocean is the broad highway of nations, tending to unite all the people of the earth into one great family, and serving to equalize the comforts of man all over the world, by wafting the productions of one country to another, exchanging the delicate products of tropical climes with the coarser necessaries of the temperate zones. By penetrating the interior of the Continents it opens up an easy means of communication between the inhabitants of inland regions and the most distant parts of the globe. The lands deeply indented by the sea have always been the cradles of civilization; Egypt, Greece, and Rome in ancient times, and the nations of Western Europe, with "our own happy isle," in modern times, illustrate this remark. By its tendency to preserve an equal temperature throughout, it moderates the heat and cold of countries bordering on the sea, the currents established in it bearing the

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† Captain Beechey, R.N., in the 'Admiralty Manual of Scientific Inquiry.'

warmth of the tropics perpetually towards the poles, and the cold of the poles towards the tropics. Its waters abound with fish and amphibious animals, which in many countries supply a large portion of the food of man. It is in itself a mine of salt, and it furnishes some of the most valuable articles of commerce. By its saltness, and the ceaseless motion of its tidal waves and currents, it becomes an incorruptible reservoir of waters, which receives and preserves those flowing from the land, and returns them in vapours and showers, without which all animal and vegetable life would perish. It is the great source of the rains that descend to fructify and nourish the earth, and in a thousand ways it ministers to the existence and comfort of man.

Throughout the whole range of universal nature there is no earthly object more calculated to impress the mind with the majesty and omnipotence of that Great Being who holdeth "the waters in the hollow of his hand" than the deep unbounded ocean. Under whatever aspectit appears, it tends to expand the soul and fill the mind with ideas of grandeur and power. Standing on the sea-shore when the ocean is taking its rest, the eye roams far and wide over its mirror-like surface, reflecting the pure light of heaven. At times it is seen perfectly calm amid the sunshine of a bright summer's day, or sleeping beneath the pale moon, its vast expanse broken only by gentle ripples just enough to reflect long lines of dazzling silvery light as they chase one another towards the shore. At other times its broad bosom heaves with long deep rolling swells, moving with slow and stately step, and breaking in snowy foam upon the far-extending shore. These heralds come to our peaceful shores, proclaiming victory, and telling us of Ocean's triumph over the storm that roused his strength some thousand miles away.

But it is only when the ocean is angry, when it has been worked to fury by the raging winds, that the mind grasps anything approaching an adequate idea of its awful grandeur. Hoary with the tempest, its giant waves roll after one another in quick succession, and in huge breakers dash with resistless fury and the voice of thunder against the rock-bound shore, sending aloft showers of feathery spray.

If such are the aspects of the ocean witnessed by landsmen, how much more striking and sublime must they be to those "that go down to the sea in ships, that do business in great waters: these see the works of the Lord, and his wonders in the deep."

# CHAPTER IX.

## INLAND WATERS.

### *Springs, Rivers, Lakes.*

*Springs.*—The waters which fall upon the land in showers or snow flow partly into the beds of the streams, which convey them to the ocean. But the greater part collects in basins and forms lakes, or sinks into the soil, and the cavities beneath the surface of the earth, and forms reservoirs, from which it issues in springs. Some of these flow constantly at all seasons, and are called *perennial springs.* Others diminish, and finally cease to flow in the dry season. Others, still, are intermitting, and cease to flow at certain periods of the year, or of the day, without any visible cause, and are called *intermitting springs.* The periodical fountain of Como, described long since by Pliny, rises and falls every hour. At Colmar, in France, there is a fountain which rises and falls eight times in an hour. Others are found which rise and fall with the tide, although they are often at a great distance from the sea. The most remarkable tide springs are those of Languedoc, in France, Torbay and Buxton in England, and Gallicia in Spain.

Most springs rise to the surface of the earth, and flow gently forth. But there are many, and especially mineral springs, that burst forth with great noise and violence, and some, like the Geysers of Iceland, throw up a column of water to a considerable height. The spouting springs of Iceland vary in their temperature from that of the air to that of boiling water. They throw out jets of water, at irregular intervals, to the height of 90 and sometimes even 200 feet, with a noise like that of cannon. The force is so great that heavy stones cast into the openings are instantly thrown out to a great height. The Great Geyser rises from a basin fifty feet in circumference, formed by the silex, or earth of flints, deposited from the water. In some parts it is loose and earthy, or siliceous tufa; but in others it is compact and hard, resembling the stone called opal.

On digging into the earth we find almost everywhere beneath the surface, though at various depths, permanent springs sufficient to supply a well. If we bore a hole beyond the surface-springs to the depth of one or a few hundred feet, in a suitable spot, we shall generally strike upon reservoirs or springs lying beneath impervious beds of clay or rock, which throw up their water to the surface, and sometimes to some distance above it. These are called *artesian wells* (so called from Artois in France, where they were first sunk), and have been found of great value in the oases of the desert, the mountains of Germany, and other places destitute of springs near the surface. Artesian wells have long been common in China and Egypt, and maintain fertility where there would be a desert without them. In the German Jura they furnish streams which turn mills, and which have the advantage of never freezing in winter. In the state of New York, and the region of salt springs, they are bored, as they have long been in China, to form brine springs for the manufacture of salt. There are several artesian wells in London and its neighbourhood.

The quantity of water in springs is various. St. Winifred's Well, or the Holy Well, in Ireland, throws out twenty tons of water in a minute, and seems like the bursting forth of a subterraneous river. A few, like the Fountain of Petrarch, at Vaucluse, in the south of France, are so abundant as to produce a river at once. But they are generally only sufficient to form a little rill. The magnificent fountain of Vaucluse is a spring of dark-blue water, of unfathomable depth, rising in a cavern, and issuing through an arch, from which it pours forth as from an urn. In the season of high water it throws out a stream capable at once of turning a mill and at a little distance forms the River Sorgne, which is navigable for boats.

The water of springs is seldom perfectly pure, as they generally dissolve some portions of the mineral substances they meet with in the earth. It is this that often renders the water unfit for washing, or "*hard*," as it is termed, in distinction from the "*soft*," or pure water of rains and particular springs, which will dissolve soap without curdling. Most springs contain some portion of lime, and many so much that they deposit a crust of limestones, or spar, on their banks and the twigs of trees, or other substances which fall into them, as is very common on the mountains of Switzerland. Others contain silex, or other minerals, which they deposit in the same manner, and which take the form of substances, or even of moulds, put into them. They are called *petrifying springs* when they destroy a substance and convert it into stone, as in the case of petrified wood; or *incrusting springs*, when they only cover shells, twigs, &c., with a crust of the mineral held in solution. The waters of Lough Neagh, in the north of Ireland, petrify hard woods when left in them for some time.

In many springs of limestone mountains a twig will be incrusted with lime in a few days, and in the Geysers with silex. In the warm springs of St. Filippo, in Tuscany, there is so much lime, or calcareous matter, that moulds of coin or medals are soon filled with a corresponding medal in solid limestone. The waters or springs of the Danube have converted the timbers of the bridge built by the Roman Emperor Trajan into solid agate. Springs which pass through beds of salt become so impregnated with it that salt is made from them. Brine springs and wells are numerous in the Western United States. Some rise to the surface, forming what are there called *salt licks*, on account of their being resorted to by wild animals to procure the salt. Other springs contain sulphur, iron, and other mineral substances or gases, which are medicinal, and render them useful in the cure of diseases. They are called *mineral springs*.

The temperature of perennial springs of moderate depth is generally about the same as the average heat of the climate of the country in which they are situated; and hence they appear cold in summer, and are warmer in winter than the surrounding atmosphere. Some springs, however, are warm, and others very hot, and are found useful as remedies in particular diseases. *Warm springs* are, therefore, classed among mineral springs, and will be described under this head, although they sometimes contain no mineral matter.

### MINERAL SPRINGS.

*Mineral springs*, as already stated, are distinguished from others by their temperature or their ingredients, and their usefulness as remedies. They frequently contain substances and possess qualities which render it almost impossible for the chemist to imitate. It is also remarkable that most of these springs do not change their qualities from age to age, except that some may vary for a short period from the effects of rain or drought. Many known in the time of the Romans are still noticed for the same properties, and are useful in the same diseases as at that period. Earthquakes have the most sensible and sudden effects upon them. One of the springs of Carlsbad, in Bohemia, lost its heat at the time of an earthquake; and a similar change took place in the waters of Buda and Toeplitz, in Hungary, and in some others, during the great earthquake of 1755.

The principal classes of springs are the *hot and warm springs*; the *sulphureous*, containing sulphur, or sulphureous gas; the *chalybeate*, or those containing iron; the *saline*, impregnated with various salts; and the *aërated*, which sparkle like fermented liquors, from the fixed air or carbonic acid gas they contain. Many springs have several of these qualities united. Indeed, it is not uncommon to find a watering place in which three or four varieties occur at a short distance from each other, as in the springs of Ballston and Saratoga, in the United States. It is stated by Brogniart, the mineralogist, that the mineral springs of primitive regions are almost always warm, and often have a high temperature. Some of these rise from beneath the granite and other primitive rocks. The principal substances found in them are sulphuretted hydrogen, or sulphureous gas; carbonic acid gas, or fixed air; soda, lime, and a little iron. In those which are found in secondary regions, carbonic acid is more rare, and lime and saline substances are the prevailing ingredients. Those of alluvial regions are usually cold; and the principal minerals dissolved are carbonate and sulphate of lime, sulphate of magnesia and iron.

Many of the hot and warm springs are impregnated with mineral substances; indeed, few of them are pure. Their usefulness frequently depends in a great measure upon their heat, and they are much employed in the cure of diseases. Volcanic countries usually abound with these springs. The boiling springs of Iceland have already been mentioned. Naples has several in its neighbourhood, and they are generally abundant in Italy. The baths of Pisa and Lucca are celebrated. Mexico abounds in hot springs, from its volcanic character; and they are particularly numerous in a tract of 40 square leagues north of Valladolid. On the plain of Jorullo is a hot, sulphureous spring, which supplies a brook twenty-four feet wide. The hot wells in the province of Guanaxuato have a temperature of more than 200° of Fahrenheit.

Bath, in Somersetshire, contains the most remarkable hot springs, forming five baths, from 93° to 117° of temperature, they are the resort of invalids from all parts of the kingdom. At the hot wells of Bristol the spring issues from a cliff on the bank of the Avon, with a temperature of 70° or 72°. Buxton and Matlock, in Derbyshire, are also noted for warm baths.

Warm springs are numerous in the middle and south of Europe. France has a number, of which Barreges and Bagneries are most frequented. Barreges contains saline and sulphureous, as well as hot, springs, from 73° to 120° of temperature. At Bagneries there are thirty-two springs, formerly known to the Romans, from 80° to 123° of temperature. The springs of Aix, in Savoy, are also much esteemed. In Germany, Aix-la-Chapelle, near the borders of the Netherlands, in the Prussian dominions, has five hot springs, used in bathing, the most celebrated and most frequented in Europe. The hot baths of Baden, in the duchy of this name, of Wiesbaden, in Nassau, and of Baden, in Austria, are also celebrated. Bohemia and Hungary have a number of warm springs. Carlsbad, in Bohemia, contains several, discovered by Charles IV., from whom the town received its name. Toeplitz is one of the principal watering-places in Germany. The name, signifying "warm springs," is applied to several villages, like German *bad* or *baden*, which signifies "bath." In Switzerland, there are valuable warm baths at Leuk, on the Rhohe, at Baden, in Argovie, Pfeffers, in St. Gall, and other places. Spain and Portugal have numerous warm springs, which are called caldas. They are found in Spain at Alicant, and in Murcia, Grenada, &c. Those of Almeria, in Grenada, are the most noted. Around the Black Sea there are numerous warm springs. At Broosa, in Asia Minor, at the foot of Mount Olympus, there are celebrated warm baths. The water is scalding as it issues from the springs. There are a number in different parts of the city; and hot and cold springs, in several instances, issue very near each other. On the east of the Black Sea, Teflis is remarkable for the warm sulphureous baths, from which it derives its name and its existence.

*Sulphureous springs* are frequently found containing a sulphureous gas, termed sulphuretted hydrogen, which renders the taste and odour offensive. Sulphur is often deposited on the borders of the springs, or in the channels through which they flow. They are particularly useful in eruptions and disorders of the skin. Those of Harrowgate, in England, are much frequented. Many of the warm springs which have been mentioned are sulphureous also.

*Chalybeate Springs*, or those which contain iron, are found abundantly in every country, in consequence of the general diffusion of this metal on the earth. They may be discovered by means of the oxide of iron, often called yellow ochre, which their waters deposit, wherever they flow, and which stains white cloth, if washed in them. *Spa* is a celebrated watering place in the Netherlands, well known to the Romans, from which the name Spa has been used as a general appellation for mineral springs. It has six or seven chalybeate springs, which issue from a hill near the town. The waters are exhilarating and pleasant to the taste. At Pyrmont, within the limits of Hanover, there is another valuable chalybeate spring, highly impregnated with carbonic acid gas. Tunbridge Wells contains the most celebrated chalybeate springs in England, and Brighton also has chalybeate waters of much value.

*Saline Springs.*—Among the *saline* medicinal springs of Europe those of Cheltenham and Epsom, in England, are among the most remarkable. They are purgative in their quality. Selters, in Germany, is well known throughout Europe for its aërated saline waters, commonly called Seltzer, and has given name to the artificial waters of this kind. Great quantities are exported to other countries. Many of the saline and chalybeate springs already mentioned are impregnated with carbonic acid gas, and thus rendered very exhilarating and more medicinal. The United States have numerous and valuable mineral springs, of various qualities.

The celebrity of many of the mineral springs described has given rise to considerable villages, like Ballston and Saratoga, in the United States; or even large cities, like Spa, in Germany, and Bath, in England, which are entirely supported by them. Instead of being visited by invalids only, they have become fashionable resorts, distinguished by gaiety and amusements during the season for using the waters.

## Rivers.

Rivers are currents of water flowing in open channels through the land. They are formed by brooks and rivulets, whose collected waters they pour into the ocean or some great inland lake. Every shower produces temporary streams, but *permanent rivers* are formed only from springs, the snows and glaciers of mountains, or from lakes.

*Sources.*—A single glacier often supplies water enough to form a considerable stream; and one spring, like that of Vaucluse, may produce a river. But the sources of a river generally comprise a number of springs or rills. Most of the large rivers have their head waters in mountainous regions. The small rills that trickle down from the tops and sides of mountains generally unite their waters and form streams, or if the ground be level, they collect in a lake from which the stream flows. The streams, again, roll through the chasms or deep rocky recesses of the mountains, or leap over precipices, forming in their descent every variety of waterfall; rolling on into the valleys they join and form rivers, enriching and fertilizing the country through which they flow, till they meet the ocean, and there expand into broad estuaries that become the channels of extensive commerce.

The magnitude of rivers depends upon the length of their courses, the area of their basins, the number of their affluents, the rain-producing character of the climate, and their connection with lofty ice-clad mountains or table-lands; but generally upon the extent of the basin whose waters it receives. This may be seen by comparing the various rivers of the earth on the map. The basin of the Amazon is the most extensive in the world, and the stream is unequalled in magnitude. The Rhine, which rises in the loftiest mountains of Europe, has a smaller basin than the Volga, and is far inferior to that river, which rises in hills only 1,200 feet high, but its basin occupies an area of 520,000 square miles. Streams often flow from the same mountains or highlands into different and distant seas. Thus the Alps send their waters to the North Sea, the Baltic and the Mediterranean. The streams which rise in the Rocky Mountains flow to the Arctic Ocean, Hudson's Bay, the Gulf of Mexico, and the Pacific Ocean. Hence the sources of rivers are often so near each other that goods can be conveyed easily from one to the other. The passage is called a *portage*, and, in many cases, becomes an important channel of commerce. In other cases, the sources are united, especially at high water, as in the Illinois and Chicago Rivers of Illinois, so that boats pass from one to the other. Douglas found a lake on the Rocky Mountains, which flows on the East into the Saskatchawan River, and on the West into the Columbia.

The margin of land separating one basin from another is called the *water-parting* or *water-shed;* this, in some cases, is a mere ridge line like the top of a house-roof, from which the waters diverge and flow down in opposite directions. The river basins indicated upon the map (No. 3) are those tracts included between the faint dotted lines, which lines represent the water-partings. The line of sources, or *the water-shed* of streams flowing in opposite directions, is not always on mountains, or on the highest points of elevations. Thus the water-shed which forms the boundary, by treaty, between France and Spain, lies north of the highest chain of the Pyrenees; and the great water-shed of Eastern Europe, between the Volga and the streams flowing into the Baltic, is found in the swamps of Western Russia.

Sometimes the sources of streams are so mingled in the same highland or table-land, that the current of one river, in its course, passes by the source of another, flowing in an opposite direction, as in the Rivers of Maine and Canada. Such streams are said to *interlock.*

*The course* of rivers signify the direction in which they flow along the regular line of descent of their valleys. But as these valleys are sometimes separated or crossed by mountains, it may either form a series of lakes, with narrow outlets or falls between them, as in the St. Lawrence, or it may pass through a chasm in the mountain barrier, and thus, in appearance, though not in reality, leave the line of descent, as in the Hudson, the Missouri, the Amazon, and many others. By the *bed* of a river is meant the channel it has excavated for itself.

The whole extent of country drained by a river, that is, the whole of the slopes which contribute their waters to the formation of a river, is called its hydrographical region, district, or *basin.* The *developement* of a river is its length from its source to its mouth, including all its turnings. A sudden change in the level of the bed of a river produces a rush or *fall* of water. When a river flows down a steep but regular descent, it forms *rapids;* when it falls over a precipice, it forms a *cataract;* and when it falls over several successive descents, it is often called a *cascade.* All these rapid portions of a river are also called *falls;* but this name is most frequently given to cataracts and cascades.

Large rivers, having their sources in elevated regions, are generally described in three portions,—*the upper course,* characterized by the union of waters; *the middle course,* forming the main body of the stream; and *the lower course,* connected with its mouth. *The upper course* is usually shallow and rapid, abounding in falls, and seldom navigable. *The middle course* is commonly deeper and more tranquil, winding through a serpentine channel, and navigable for boats with few interruptions. *The lower course* is generally a powerful, but often a sluggish stream, navigable for sea-going vessels, and frequently spreading into numerous channels and branches, or forming a delta.

The regularity, number, and extent, of these divisions vary, of course, with the character of the country through which a river flows. Where a mountainous region touches on the sea, as in Norway, the streams are mountain torrents, with an upper course only; but where a terrace, or a moderate declivity, intervenes between the highlands and the lowlands, we find all these divisions distinctly marked. Streams which rise from regions of moderate elevation, like the Volga, have a short and tranquil upper course, and often a long middle course. The extent of the lower course depends on the breadth of the lowland through which it flows. The streams of table-lands frequently form the upper part of rivers which empty in the lowlands. But so long as they flow upon the plains, they are naturally tranquil streams, and their most rapid and turbulent portion will frequently be in the middle, or at the end of their course.

*Descent and Rapidity of Rivers.*—The descent of streams, in their upper course, is often very great. In the Andes, many streams rise at an elevation of 8,000 or 10,000 feet above the level of the sea, and flow through deep valleys, or chasms, which they fill with their waters, until they issue from the mountains, at the height of 1,000 or 2,000 feet. The Rhine, the Reuss, the Tessino, and other streams of the Alps, fall from 3,000 to 4,000 feet in a few stages, in their mountain course. The current of a river is at first occasioned by the weight of the waters descending a declivity. But the pressure on the lower portions of the stream, produced and maintained by this, often pushes them on rapidly, over ground that has very little descent, in their middle and lower courses, as in the Amazon and the Rhine. The Rhine, which falls 4,000 feet before reaching Basle, descends only 555 feet, or 2¼ feet in a mile, between Basle and Mayence. The Seine, in its lower course, falls only one foot in a mile; the Amazon, which falls 10,000 feet in its upper stream, descends only 40 feet in the last 400 miles of its course, or 1-10th of an inch to a mile; and the Paraguay falls only 1-33rd of an inch. Notwithstanding the diminished rapidity of the current in the lower course of a river, it is often so powerful that its waters may be distinguished from those of the ocean, at some distance from the shore, especially during a flood, as in the Amazon and Orinoco. Columbus found his vessel in the fresh water of the Orinoco, before he discovered the continent of America. The waters of the Amazon are said to remain fresh for 240 miles from the coast. A British fleet occasionally found fresh water at the mouth of the Rhone, at some distance from the shore; and the mud of the Mississippi discolours the sea water, out of sight of land.

The velocity of a river depends upon its volume of water, the form of its channel, the slope of its bed, and the nature of its windings, which cause the stream to be retarded by impinging against the banks. The rapidity of a stream is various in the different parts of its course. The average rapidity of the Rhine, the Ganges, and the Nile, in their middle course, is from three to four miles an hour; that of the St. Lawrence, in its lower course, about three miles. Where a narrow passage, or sudden descent, produces rapids, or a river is swollen by a flood, it is often three or four times as great. In rivers which have numerous windings, the current, striking against the bank, is often, in part, thrown back, and forms a counter current, or eddy which flows up along the shore for some distance, and aids boats in ascending the stream. In general, the rapidity of rivers which have a serpentine course, is less than that of those which flow in a straight channel, and the difficulty of navigation upward is thus diminished, although the distance is increased.

*Union of Rivers.*—The basins of rivers are sometimes so nearly on a level that their waters flow together, usually in the middle or lower course. Thus the Cassiquiare, a large, navigable stream, unites the Orinoco with the Rio Negro, a branch of the Amazon, so that these two great rivers are connected. This kind of union occurs most frequently in such as pursue nearly a parallel course, as in the Pegu and Irrawady, the Mecon and Cambodia, and the Ganges and Brahmaputra, of India. It is found, also, in those whose sources are near each other, but which separate widely in their middle courses, and unite in their lower courses, as in the Euphrates and Tigris, and the Hoang-Ho and Yang-tse-kiang, of China. Such rivers are called twin streams. The Euphrates and Tigris inclose the region called Mesopotamia The corresponding region of China is called by the natives, "The Central Flower," or "Jewel of the Kingdom," on account of its fertility.

*Irrigation by Rivers.*—The waters of rivers are sometimes spread over a country by means of canals, in order to irrigate it more fully. They are not, however, in general, confined to their beds, but spread into the soil on both sides, and thus supply a considerable tract of country with that permanent moisture which secures it from drought and barrenness, even in hot regions, as in Egypt. This is proved by the water being found for some distance from a stream, on digging down to its level. This distance varies with the magnitude of the stream and the nature of the soil. In Egypt, traces of the Nile are found at the distance of two days' journey; and Strabo observes, that all Egypt is the property of the Nile, from being thus penetrated by its waters, and rendered a fertile oasis between two deserts. While the spreading of the waters beneath the surface of the earth extends the beneficial influence of a river, it diminishes in proportion to the quantity of water in its bed, and renders its course less rapid. The Gihon of the Sea of Aral diminishes visibly as it proceeds, on this account. Where the soil is very sandy or porous, it sometimes absorbs the water so rapidly, and allows it to evaporate so fast, that the stream is lost imperceptibly, or terminates in a lake of greater or less size, where it evaporates, without reaching the ocean. Numerous streams are thus lost in the dry plains of South America and Asia, and in the Great Desert of North America, and are called *steppe rivers.* Those of the Caspian Sea, and the Sea of Aral, belong to the same class. In countries abounding in chasms and caves, as is usual where limestone prevails, rivers sometimes sink into them, and disappear. Most of them rise again at some distance. The Rhone is thus lost, soon after leaving Switzerland, and rises again at the distance of 300 feet. The Guadiana of Spain pursues a subterranean course for several miles; instances of the same kind occur in Europe.

*Mouths of Rivers.*—Streams which pursue their course to the sea are called *oceanic rivers,* and terminate in mouths whose character varies with that of the coast. On a high, rocky coast, it is generally a single deep channel or bay, like the friths of Scotland, and the deep fiords which form the mouths of the rivers in Norway. On low coasts, bordered with sands or marshes, the force of the waves, and of the current, is so checked by the sea, that the rivers generally deposit the sand and mud which they contain, and form bars which render the entrance shallow, or sand-banks, which inclose a lagoon, as along the coasts of the United States, and of Russia, and South America. On some coasts of this kind the alluvial soil, held in suspension by rivers, gradually settles down as the currents slacken, and forms portions of land termed *Deltas*, so called from their triangular shape, resembling the Greek letter Δ. At the mouths of the Ganges, Nile, Volgo, Rhine, Mississippi, and Orinoco, there are large deltas, and those of the Brahmaputra, Po, and Rhone, are of considerable extent: there are deltas also in the Adige, Brenta, Isonzo, and Tagliamento.

*Water of Rivers.*—In their rapid mountain course rivers generally tear away, and carry with them, not only earth and sand, but fragments of rock, which are reduced first to rounded pebbles, and a part of them at length, to sand and soil. Hence the water of a river is seldom clear in its upper course, but, on reaching the middle course, where it flows more gently, and especially where it expands into a lake, it deposits these substances, and becomes clear, often with a beautiful blue colour, like that of the deep sea or the lofty glaciers; as in the Rhone, where it issues from the Lake of Geneva. In its course, it also deposits lime, iron, or other mineral substances, which may have been dissolved in its springs, and thus becomes the purest kind of water. The water of the Thames, the Elbe, the Delaware, and the Mississippi, preserves its sweetness longer at sea than that of springs. Streams which flow from, or pass through, regions strongly impregnated with salt or acids, are often rendered impure. Thus many of the steppe rivers of Asia and South America are rendered excessively salt, by the salt plains through which they pass. The Rio Vinaigre, rising from a volcano in South America, is so sour as to destroy fish that enter it. The Rio Vinaigre (or Vinegar River) rises on the sides of the Volcano Purace, above the city of Popayan, and forms three fine cascades, one of which is 300 feet in height. It was found by Humboldt so strongly impregnated with sulphurous acid, as to destroy the fish for a distance of twelve miles. Similar but smaller streams sometimes flow from the volcanoes of Java, and destroy the vegetation in their course. Some entire streams partake of the impregnation and the petrifying qualities belonging to the springs already described. The Anio, as it falls over the rocks of Tivoli, near Rome, produces stalactites of calcareous spar, from the foam of its cataracts, and forms a bed of limestone beneath, by its deposits.

*Oceanic rivers* are those which pour their accumulated waters into the sea. The Pacific, though the largest ocean of the globe, has but few rivers of long courses falling into its immense basin. The basins of the Atlantic, Arctic, and Indian Oceans receive most of the continental streams,—some of the mightiest floods discharging their waters into these vast recipients. *Continental rivers* are those which never reach the ocean, but fall into lakes unconnected with it, or are absorbed and lost in swamps, marshes, or sandy deserts.

Notwithstanding a much smaller extent than that of the Old World, the New possesses the largest rivers on the earth; the richest in waters, those whose basins occupy the vastest spaces. Where can we find, on the surface of the globe, a river equal to the mighty Maranon, that giant among the rivers of the earth, gathering its waters from a surface of a million and a half square miles, and bearing them to the ocean after a course of nearly 3,000 miles. This mighty monarch receives in his progress the homage of tributaries, each of which, by its greatness and the abundance of its waters, would suffice for the wants of a whole vast country. Such are the Ucayale, the Rio Purus, the Rio Negro: above all, the Madera, rivalling in importance the river to which it yields the honour of giving a name to their united waters. The farther it advances in its majestic course, the more its proportions increase; and before arriving at the ocean, its broad sheet, from the middle of which the eye cannot reach the banks, seems rather to be a freshwater sea, flowing sluggishly towards the ocean basin, than a river of the continent.

"This noble stream, which exceeds in magnitude the largest rivers in the Old World, takes its rise from two sources, the one of which is found in the glaciers of Lauricocha (one of the loftiest of the Cordillera range), the second in the snowy summit of Mount Cailloma, in the same lofty chain. Swelled by the tributary streams of the Yupura and the Rio Negro on the left bank, and by the Yavari, the Yutay, and the Yurna, the Mugua, the Rio de los Capanachuas, and the Pachira, on the right, it flows for a long period through mountain gorges of prodigious depth and surpassing beauty. After emerging from the Andes, it winds in a lazy current through the immense savannahs of South America, and does not reach the ocean till it has run a course of 315 leagues.

after its junction with the Rio Negro. From its source to the sea is 1,035 leagues, or 2,700 miles. Its breadth, after it emerges into the plain, is generally from two to three miles, and its depth is seldom less than eighty fathoms. After its junction with the Xuaga, however, its expanse becomes so great that in mid-channel the opposite coasts can hardly be seen, and it flows in a vast estuary, so level that the traces of the tide are seen at the distance of 250 leagues from the sea coast. A vehement struggle ensues at its mouth between the river flowing down and the tide running up; twice every day they dispute the pre-eminence, and animals equally with men withdraw from the terrible conflict. In the shock of the enormous masses of water, a ridge of surf and foam is raised to the height of 180 feet; the islands in the neighbourhood are shaken by the strife; the fishers, the boatmen, and the alligators withdraw trembling from the shock. At spring tides, such is the vehemence of this collision, that the opposite waves precipitate themselves on each other like hostile armies; the shores are covered to a great distance on either side with volumes of foam; huge rocks, whirled about like barks, are borne aloft on the surface; and the awful roar, re-echoed from island to island, gives the first warning to the far-distant mariner that he is approaching the shores of South America."—*Alison's History of Europe: Description of South America, in the Art. South American Revolution*, vol. viii., p. 385.

In the other continent, the "father of waters," the mighty Mississippi, the second of the rivers of the earth, equals in length the Maranon itself, for its winding course is 3,000 miles, but its basin covers only from 800,000 to 900,000 square miles.

"Already a noble river when it issues in the solitude of the far west from the Rocky Mountains, its passage into the plain is worthy of the majestic character of the great father of waters. Between stupendous walls of rock, 1,200 feet high and 3 leagues in length, whose overhanging cliffs darken the awful passage, it issues forth in a deep and moaning current 300 yards broad, and, soon swelled by other tributary streams, winds its long and solitary way through the prairies to the falls,* 60 miles distant, which rival Niagara itself in sublimity and grandeur. The Mississippi, the Ohio, the Tenessee, the Illinois, the Arkansas, the Kansas, the White River, the Red River, the St. Peter, the Ouisconsin, any one of which exceeds the Rhine or the Danube in magnitude, and some of which have given their names to the mighty states which already are settled on their shores, are but the tributaries of this prodigious artery. These various rivers, all of which are navigable, each with their own affiliated set of tributary streams, several thousands in number, form a vast chain of inland navigation, all connected together, and issuing into the sea by one channel, which, like the arteries and veins of the human body, is destined to maintain an immense interior circulation, and convey life and health to the furthest extremities of the million of square miles which constitute the magnificent garden of central America.

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* They are in all, 384 feet in height; the principal fall alone is 220 feet high, and about 800 broad. They are surmounted by lofty cliffs, and their roar is heard thirteen miles off. In a solitary tree on an island, in the middle of one of the falls, an eagle has built its nest.

"If the majestic portals by which the Missouri issues from its icy cradle in the Rocky Mountains is one of the sublimest, the alluvial swamps through which it finds its way to the ocean in the Gulf of Mexico is among the most interesting objects in nature. There one of the great formations of the earth is actually going forward: we are carried back to what occurred in our own continent before the creation of man.

"Like all other great rivers, the Missouri, or the Mississippi, as it is there called, does not empty itself into the sea in one continuous channel, but in a great variety of arms or mouths, which intersect in sluggish streams the great alluvial delta which is formed by the perpetual deposit of the immense volume of water which rolls into the ocean. Between these mouths of the river a vast surface, half land half water, from 50 to 100 miles in width, and 300 in length, fringes the whole coast; and there the enormous mass of vegetable matter constantly brought down by the Mississippi is periodically deposited. A few feet are sufficient to bring it above the level of the water, except in great floods; and as soon as that is done vegetation springs up with the utmost rapidity in that prolific slime. No spectacle can be conceived so dreary, and yet so interesting, as the prospect of these immense alluvial swamps in the course of formation. As far as the eye can reach, over hundreds of square leagues, nothing is to be seen but marshes, bristling with roots, trunks, and branches of trees. In winter and spring, when the floods come down, they bring with them an incalculable quantity of these broken fragments, technically called logs, which not only cover the whole of this immense semi-marine territory, but, floating over it, strew the sea for several miles off to such an extent that ships have often no small difficulty in making their way through them. Thus the whole ground is formed of a vast net-work of masses of wood, closely packed and rammed together to the depth of several fathoms, which are gradually cemented by fresh deposits, till the whole acquires, by degrees, a firm consistency. Aquatic birds, innumerable cranes and storks, water serpents, and huge alligators, people this dreary solitude. In a short time a kind of rank cane or reed springs up, which, by retarding the flow of the river, collects the mud of the next season, and so lends its share in the formation of the delta. Fresh logs, fresh mud, and new crops of cane go on for a series of years, in the course of which the alligators, in enormous multitudes, fix in their new domain, and extensive animal remains come to mingle with the vegetable deposits. Gradually, as the soil accumulates and hardens, a dwarfish shrub begins to appear above the surface; larger and larger trees succeed with the decay of their more stunted predecessors, and at length, on the scene of former desolation, the magnificent riches of the Louisianian forest are reared."—*Ibid.*

The Ohio, "the beautiful river," the stream with transparent waters, like the Arkansas and so many others composing that vast system of arteries that vivify the whole west, are destined to assume daily a greater and greater importance. These immense rivers are not isolated. Near to the Maranon, the La Plata has a course of not less than 1,900 miles, and more than a million of square miles send in their waters. Near to the Mississippi, the St. Lawrence has a course of 1,800 miles, and a basin of nearly a million of square miles. The Old World offers nothing similar. The greatest of its rivers, the Yan-tse-kiang, in China, has a course of only 2,500 miles. The Ganges and the Nile are far from equalling it. The Volga, the greatest of the rivers of Europe, exhibits a course of only 1,700 miles; and if it were necessary to enumerate in America rivers like the Rhine, so celebrated, it would be almost by hundreds that we should have to cite them.

*Floods of Rivers.*—Rivers have their periods of growth, and decline, like plants, and generally at corresponding seasons, consisting in the increase and diminution of their waters.

In the Torrid Zone, their waters increase to floods during the wet season, and diminish or disappear during the dry season; so that we find a distinct name for "rivers without water," in the languages of this zone. In the Frigid Zones, they are hardened to ice in winter. This is the period of rest, and spring and summer are the seasons of revival and vigour. In the Temperate Zones, the changes are various in degree and time, according to the situation. In regions of frost, the rivers are covered with ice, and become solid roads during the winter. In the dry season of hot countries, the traveller often crosses the beds of streams dry shod, and uses them as roads. Thus the Orange River of South Africa is sometimes without water for several years. In the spring of frosty regions, the melting of the snow and ice not only carries away the icy covering, but generally swells the stream, so that it overflows its banks, or produces a flood. The breadth of the stream, and the masses of ice it brings down, make the breaking up of the river generally a scene of sublimity, but often of extensive destruction. The rivers of North America often bring with them, in their spring floods, masses and fields of ice, whose force nothing can resist. They are sometimes piled up in narrow or shallow places, or against bridges, or other obstructions, and produce a lake, which spreads far around, and, when it bursts its barrier, destroys everything for a considerable breadth on the banks below.

*In the Torrid Zone*, the rains of the wet season descend in such torrents that they soon fill, not only the beds of the streams, but almost every valley, and drive the inhabitants to the highlands. The streams swell gradually to broad lakes or seas, which cover the land sometimes for months, so that it is necessary to construct permanent dikes and channels to restrain and regulate the course of the waters, and prevent the devastation of the country. A single flood of the Ganges has destroyed from 50,000 to 100,000 persons. The greatness of the change is scarcely conceivable to an opposite region. The Tacazze, a branch of the Nile, the Orange River of Africa, the rivers of New Holland, and many other streams of considerable magnitude, scarcely flow in the dry season, and often present only a dry bed, or a few scattered lakes. But in the wet season, they swell to mighty streams and broad lakes. The Amazon and the La Plata cover their basins with one wide sea, sprinkled with islands.

In the Temperate Zones, the floods are less uniform in their period and character. They vary not only with the climate, but with the changing character of the year, and depend much on the vicinity of the mountains, the quantity of rain and snow, and the recurrence of thaws and storms. Streams which flow immediately from mountains covered with perpetual snows, like those of the Alps, rise daily as the heat increases, and fall as it diminishes. Many of these are only [illegible] which are dry in winter, when snows no longer melt.

In warmer countries, or those in which the mountains are covered with snow only in winter, violent torrents are often formed during the winter or spring, in beds which are dry throughout the summer, as in Greece, Italy, and Spain. Most large rivers of the Temperate Zones are subject to annual or semiannual floods of greater or less extent. The St. Lawrence is almost the only one known, which is not sensibly affected by seasons or weather. The high water and floods of warm countries, as Italy, usually occur during the winter; those of colder countries during the melting of the snows in the spring, and the rains in autumn; but in either, the streams are liable to floods, at other seasons, from occasional thaws or violent storms. Those which receive a large part of their waters from the snows of lofty mountains, like the Rhine, are often highest during the hot season.

In rivers which flow from east to west, like the Orinoco, and thus have the same seasons in every part of their course, the increase is nearly uniform, at the same time, in every portion. In those which flow in a meridional direction, like the Nile or the Mississippi, the flood does not take place at the mouth until some time after the thaws or rains at their sources. Rivers which receive numerous branches from an extensive basin, like the Mississippi, are of course irregular in their floods, from the variety of climates and seasons at the sources of their waters. In streams which flow from a cold to a warm portion of the Temperate Zone, the high water begins near the mouth, and gradually extends to the sources with comparative gentleness. In those which flow towards a colder region, the waters which come from the melting sources often find the lower course covered with ice, and produce devastating floods, as in Mackenzie's River, and others of the Arctic Ocean. The floods of the Nile, the Ganges, and the Mississippi, rise about 30 feet above the common level. The Ohio, and other branches of the Mississippi, often rise 40 or 50 feet; and the Orinoco, from 70 to 120 feet. The floods of the Orinoco, the Amazon, and the Ganges, cover the country for 100 miles in breadth. In the floods of the Mississippi, its waters flow down on the adjacent country, producing an extensive range of swamps. It has been necessary, on this account, to protect the cultivated lands by an embankment, called the levee, which extends for the distance of 200 miles on the eastern shore of the river, and 300 on the western.

Although the floods of rivers are often destructive, sweeping away houses and villages, they are generally very useful, by leaving behind them a deposit of vegetable mud or slime, which renders the vales of the rivers the most fertile spots on the earth. Egypt is entirely dependent on the floods of the Nile, for watering, as well as fertilizing, its lands. The level of rivers falling into the sea usually varies with the tides for a certain distance from their mouths, depending on the obstructions of the current and channel. In the Amazon, the tide is perceived 400 miles from its mouth ; in the Thames 70 miles. In the Connecticut, it ascends 50 miles.

*Tidal rivers*, or those which fall into tidal seas, have the level of their lower course, for some distance, changed daily by the tidal wave.

The current of the river, in meeting with the tides or waves of the sea, sometimes produces an elevated ridge of waters, which obstructs the passage of ships. The force of the sea often prevails against the current, and a mountain wave rolls swiftly up the stream, overturning boats, inundating the banks, and often producing extensive destruction. This phenomenon is called the *bore*, which comes rolling in with the first of the flood, and, rising to the height of from 5 to 15 feet above the level surface of the river, with a foaming crest, rushes onward. At the mouth of the Garonne it is called the *mascaret*. At the junction of the Tigris and Euphrates it is called *bar*. In the Hooghly, one of the mouths of the Ganges, it is known as the *bora*, and in the Amazon it bears the name of the *rollers*, but by the Indians it is called *pororoca*. In the Garonne and Amazon, it occurs twice a day, at the time of high tide. At the mouth of the Ganges, it occurs three times during every rise of tide ; and the water often rises 5 feet instantaneously at Calcutta. High water, and even inundations, are sometimes produced by strong winds or high tides opposing the current of a river, and in some instances have been very destructive. The eastern extremity of Lake Erie is sometimes raised several feet by a westerly wind ; and the rivers of Germany are raised for a great distance by a wind at their mouths blowing against the current. The navigation of the Lower Elbe often depends on the direction of the wind.

*Comparison of Rivers.*—Rivers may be compared in regard to their length and width, but the most important differences, in their influence on man, are the extent of navigation, and, especially, the magnitude of the basin, which forms a natural kingdom, whose parts are closely connected by one common governing stream. The width of a stream sometimes varies with that of its valley, but generally it depends on the quantity of water. The length of a river may be measured either along its windings, or in a direct line from its source to its mouth. The difference between these, or the extent of its windings, is called the *development* of a stream. The greater this development is, and the more serpentine its course, the more widely does it water and fertilize the soil and extend internal commerce ; and this is more important than the mere length of its course. Thus the Dniester varies but a few miles from a straight course. Hence it has a narrow basin and few branches; and although it is one of the longest rivers in Europe, has little influence on its fertility or commerce. On the contrary, the Vistula makes a large curve and receives numerous branches, and thus fertilizes an extensive region, and furnishes a channel for the transportation of the produce of a large part of Poland to the Baltic Sea and distant parts of Europe. The Mississippi, by its numerous branches and windings, confers these benefits on a far more extensive region than the St. Lawrence, with its more direct course and fewer branches.

The extent of navigation in a stream depends on the form and geological structure of its basin, and the character of the valleys in which it flows. The streams of highlands, and the upper courses of others, are seldom navigable, while those which flow through lowlands, or plains, are often navigable, even to their sources. The rivers of longitudinal valleys are generally more navigable than those of transverse valleys. Those of terraced valleys are occasionally interrupted by falls, or rapids, in passing from one basin to another. Streams which are little developed, or flow nearly in a straight line, often admit of no navigation upward, on account of the rapidity of the current, unless with the aid of the tides ; and it is always difficult to ascend them. In streams which are more developed, or serpentine in their course, the length of navigation is increased ; but the labour of ascending the stream is greatly diminished by the diminished rapidity of the current, and the eddies, or counter-currents, along the banks.

### I. *River Systems of the Great Continents.*

Upon referring to the Map No. 3, we observe that, though

Europe is one of the smallest divisions of the earth, yet it enjoys throughout its whole surface the benefit of a well-developed river system. Asia sends forth in all directions large river-veins from its mountain regions, but its great central table-land is scantily supplied with water, and Arabia is nearly destitute of this necessary of life.

Africa is less favoured with running waters than any of the other divisions of the earth; this may be accounted for partly by the position, elevation, and extent of its great southern table-land. The drainage of America is on a most splendid scale; numerous rivers spread themselves over its western and central regions, and, there uniting, roll on with the majesty of seas to the ocean.

*The course* or direction of rivers depends upon the distance the highlands in which they take their rise are from the sea, together with the geological nature of the country through which they flow. The direction of the course of rivers is generally at right angles to the mountain chains from which they flow; thus the Indus, Ganges, and Brahmaputra, flow at right angles to the Himalayan chain, and the Siberian rivers in a similar direction from the central regions of Asia: several of the European rivers follow this law, as also the African rivers, the Nile and Niger. In America, almost all the rivers, with the exception of the Rio Colorado and the Magdalena, flow at right angles to the great mountain chains.

The most extensive basins and the largest rivers are found on the Western Continent. The Amazon, the La Plata, the Mississippi, and the St. Lawrence, surpass all other rivers on the globe in magnitude, and in the extent of their basins, except the Obi of Siberia.

The basin of the Amazon is equal in extent to half of Europe; its length is nearly 4,000 miles, and its mouth 50 miles in width; so that the navigator can see but one bank. The Mississippi is equally long, with a basin equal to one-third of Europe. Its average breadth is 1½ miles, and its depth 150 feet in its lower course.

The waters of the St. Lawrence expand into a chain of lakes, which cover a surface of 90,000 square miles. The La Plata, is unrivalled for the size of its estuary of fresh water, 150 miles wide, on which ships may sail without seeing the land.

The American rivers are equally remarkable for the extent of their navigation. Steamboats can ascend the Mississippi more than 3,000 miles, and the Missouri nearly 4,000 miles, from the sea. The Amazon is navigable for large ships for a great distance, and for smaller vessels for a considerable part of its course. The St. Lawrence, except in two or three points of interruption, is navigable for ships for a distance of 380 miles direct from the ocean.

Next in rank are the Hwang-Ho, the Yang-tsze-Kiang, and Amour, of China; the Lena and Yenesei, of Siberia; the Volga, and the Nile. The two first are 2,600 miles in length, and the rest above 2,000, with a breadth of 1 or 2 miles in some parts, and seldom less than ¼ of a mile in their lower course. The Volga is navigable nearly to its sources, and the Nile for a large part of its course.

The Orinoco, the Ganges, the Indus, the Columbia, the Rio del Norte, the Danube, and the Euphrates, all have basins equal, or superior in extent, to the empire of Austria; while the length of their windings varies from 1,460 miles in the Ganges, to 1,630 in the Danube. The mass of waters in the Orinoco is such that its mouth is 25 miles wide.

The rivers of Europe, except the Volga, are inferior in length to those already mentioned, though valuable for navigation. In Africa, the Nile is the only great river, except the Niger, which is not yet fully explored, but is probably superior to the Nile.

All rivers within or adjacent to the torrid zone, such as the Ganges, Niger, Orinoco, and Amazon, have their floods at very regular periods; they begin to swell about the 25th of March, and arrive at their full, and begin to decrease, about the 25th of August. There is a remarkable contrast between the rivers that roll through the great American plain and those that traverse the Asiatic northern level, though they have their head-waters about the same distance from the equator. The great tributaries of the Mississippi become gradually unlocked from ice, one by one, in the direction from south to north, and have their sources opened last: were the whole of these tributaries to be opened by the action of the sun at the same time, they would let forth their waters and sweep everything, animal and vegetable, from the surface of the plain. The head-waters of the Siberian rivers are first opened by the solar influence, and, being checked by the ice still binding their lower course, burst forth, inundating the plains for several miles on either side of their banks.

The river systems of Asia, though on a more splendid scale, somewhat resemble those of Europe; the Ebro may be compared with the Euphrates, the Rhone to the Indus, the Po to the Ganges, and the Grecian streams to those of the Malayan peninsula.

The principal rivers in each continent, with their lengths and the areas of their basins, are given in Map 3; and in the Table of Rivers will be found a more extended list, exhibiting similar elements; but the results there shown must be taken merely as approximations.

## II. *Influence of Rivers upon Commerce and Civilization.*

The part assigned to rivers in the general economy of nature is beautifully explained in the following paragraph, from the pen of Dr. Arnott:—*

"As in the animal body, from every the minutest point, a little vein, endowed with living power, takes the blood which has just brought life and nutriment to the part, and delivers it into a larger vein, whence it passes into a larger still, until at last, in the great reservoir of the heart, it meets the blood returned from every part of the body; so in this terraqueous globe, where the magic moving power is simply fluid seeking its level, does the rain, which falls to sustain vegetable and animal life, and to renovate nature, glide from every point of the surface into a lower bed, and from thence into a lower still, until the countless streams so formed, after every variety of course, combine to form the swelling rivers, which return the accumulated waters into the common reservoir of the ocean. In the living body the arteries carry back the blood with renewed vitality to every point whence the veins had withdrawn it, and so complete the circulation; and, in what may be called the living universe, the circulation is completed by the action of heat and of the atmosphere, which, from the extended face of the ocean, raise a constant exhalation of watery vapour of invisible purity, which the winds then carry away and deposit, as rain or dew, on every spot of the earth."

Rivers have in all ages exerted a wonderful influence upon man and his habits. It was on the banks of rivers that civilization first began to dawn. The Tigris and Euphrates watered the earliest habitations of man, and the land lying between them, called from this circumstance 'Mesopotamia,' was the seat of the earliest civilization. Subsequently the arts and sciences flourished on the banks of the Nile, and at the present day we find almost all large cities on the banks of rivers. If we look at new countries we find that immigrants spread themselves along the banks of rivers; in this way the valley of the Mississippi is yearly filling up. Rivers have often assigned the boundaries to counties, and even to countries, and in a thousand ways they are subservient to the uses of man. But besides the material service they render him, they have always exerted a mysterious influence on his modes of thought. Those who dwell on the banks of a river generally become attached to it. The natives of India pay divine homage to their Ganges. The Egyptians speak of their Nile with the intensity of personal affection. Its praise has passed into proverbs, and it is said that no one ever drank of the waters of the Nile without being irresistibly impelled to drink of them again. Nor has our own Thames been without its devoted admirers; many of our great poets, Gray, Thomson, Waller, and Sir John Denham have sung its praises.

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* 'Elements of Physics.'

Poets and orators, of all ages, have moralized on the resemblance between the course of a river and the progress of human life, and the similitude is thus beautifully traced by the celebrated Robert Hall:—

"The life of every individual may be compared to a river: rising in obscurity, increasing by the accession of tributary streams, and, after flowing through a longer or shorter distance, losing itself in some common receptacle. The lives of individuals also, like the course of rivers, may be more or less extensive, but will all vanish and disappear in the gulf of eternity. Whilst a stream is confined within its banks it fertilizes, enriches, and improves the country through which it passes; but if it deserts its channel it becomes injurious and destructive, a sort of public nuisance, and by stagnating in lakes and marshes its exhalations diffuse pestilence and disease around. Some glide away in obscurity and insignificance, whilst others become celebrated, traverse continents, give names to countries, and assign the boundaries of empires. Some are tranquil and gentle in their course; whilst others, rushing in torrents, dashing over precipices, and tumbling in waterfalls, become objects of terror and dismay. But however diversified their character or their direction, all agree in having their course short, limited, and determined; soon they fall into one capacious receptacle, their waters eventually mix in the waves of the ocean. Thus human characters, however various, have one common destiny; their course of action may be greatly diversified, but they all lose themselves in the ocean of eternity."

### *Lakes.*

Lakes are basins filled with water which does not flow in from the sea. They are, generally speaking, numerous in high latitudes and in certain elevated regions. Most lakes discharge their waters through a stream flowing into a river, or the ocean, and these generally have fresh water. Some are supplied only by springs, and form the sources of rivers. Others receive and discharge rivers, and are, in fact, mere expansions of the stream, which spreads itself over plains too level for a continued current, or in the enclosed valleys through which it passes, like the great lakes of North America. Thus the lake of Geneva is only an expansion of the Rhine, and Lake Constance of the Rhone. The River Irtish forms and passes through Lake Nor. Lake Baikal is traversed by the Angara, and the Abyssinian Nile expands into the Lake of Dembeah. The great lakes of North America are only expansions of the waters of the St. Lawrence.

Some lakes are formed periodically in this manner, during floods, and disappear when they subside. Lake Xarayes, on the Paraguay River, is an example of this kind, and has been alternately drawn and effaced on the maps of South America.

Lakes of another class have no visible outlet. Some of these receive no streams, like the lake of Albano, near Rome, and others found in the craters of extinct volcanoes, and the cavities of lofty mountains. Others receive rivers, and have no visible discharge, like the Dead Sea, but the water is probably carried off by evaporation. As there is no current to convey away the salts continually washed in from the surface of the land, such lakes are always salt, except in a few instances in mountainous regions. The Caspian Sea, the Sea of Aral, and most of the lakes of Asia, Africa, and South America, are of this kind; but they are rare in Europe and North America. The celebrated Lake Asphaltites, or Dead Sea of Syria, is remarkable for the excessive saltness and bitterness of its waters. They are said to destroy the fish brought into it by the River Jordan. Lake Van, in Armenia, which is 168 miles in circumference, is quite brackish; Lake Urumea, or Ooroomea, on the border of Persia, which is 300 miles round, is said to be the saltest lake known.

Salt lakes are particularly abundant in hot countries, and the dry and desert regions of Asia, Africa, and South America. These often evaporate in the hot season, and leave a crust of salt on their beds, which thus becomes highly valuable. Some lakes contain soda, or natron, which collects on the bottom in a similar manner. The most celebrated are the six natron lakes of Egypt, lying west of the Nile, which furnish large quantities for commerce. Such lakes are numerous in Hungary, and are found in Mexico and New Grenada. A lake in Maracaybo, in South America, deposits more than 1,000 pounds in two years, which is taken from the bottom by Indian divers. In Tibet, there is an insulated lake which deposits a peculiar salt, the borax or tincal of commerce, which is much used in soldering metals.

In the largest lakes, like those of North America, already mentioned, the level of the waters is rarely affected by rains or drought. Smaller lakes are often materially changed; and some, as has been already stated, become entirely dry in the hot season. Others sink away, periodically, into the earth. The Lake of Cirknitz, in Illyria (Austria), is remarkable for losing its water through a number of apertures in the bottom, during the summer.

Large inland waters, like the Caspian Sea, and the lakes of North America, are subject to storms as violent and dangerous as those of the ocean. They are more sudden, and more unsteady, on account of the mountains, which interrupt and vary the winds. Lakes are often celebrated on account of the scenery around them, which of course varies with the peculiar character of the country. The lakes of mountainous regions, like those of the Alps, of Norway, Sweden, Scotland, and Finland, are distinguished by the wild and romantic character of their scenery. Their shores are usually lined with rugged precipices and dark forests; and they are often studded with rocky islands, which add to their beauty. Lake Maler, in Sweden, is said to have 1,200 islands, several of which are covered by the city of Stockholm. The Lakes of Geneva, Neufchatel, and Lucerne, which are celebrated for their beauty, are situated among the Alps, more than 1,200 feet above the level of the sea.

In mountainous or hilly regions, of moderate elevation, the lakes are bordered by gentle, undulating banks, often highly cultivated, and exhibiting the softer beauties of the landscape, as the lakes of Northern Italy. Lakes Maggiore, Como, and others, which lie at the foot of the Alps, and extend into the plains of Italy, have all the grandeur of these mountains on the north, while they are surrounded, on all other sides, by the rich beauties of a cultivated landscape.

The lakes of flat countries seldom possess much natural beauty. They are often mere stagnant pools; and in some cases they produce unhealthy exhalations, from the marshes which border on them. Many of them are mere lagoons. Lakes of this kind are frequent on alluvial coasts, and especially at the mouths of large rivers, like the Nile and the Mississippi. They are formed by the bars and shoals common to such regions, and are usually connected with the sea, so as to partake of its saltness. The shores of the Gulf of Mexico are lined with these lakes.

North America is distinguished for the size of its lakes. The group of the great lakes of Canada, so characteristic of North America, finds nowhere a parallel. It contains at once the largest lakes in the world, and the greatest mass of fresh water united on the surface of the globe. These vast seas of fresh water, together with the St. Lawrence, cover a surface of nearly 100,000 square miles, and it has been calculated that they contain almost one-half of all the fresh waters on the surface of our planet. They, too, are not alone, a glance at the map enables us to perceive in the north a multitude of lakes but little inferior in extent; the lake Athapescow, Winnipeg, Slave Lake, and the Great Bear, are worthy to range side by side with the lakes of Canada and of the St. Lawrence.

The rivers and the lakes are the wealth, and justly form the boast of America. No continent possesses so great a number, or those of such large extent, so well provided with water, and so navigable. Not only do they fertilize the rich countries they traverse, but they are now, and will become still more so, the great highways of commerce between all the parts of this vast world. The lakes of Nicaragua, in Guatemala, and of Maracaybo, and Titicaca, in South America, are also very large bodies of water. These, as well as the great lakes of North America, are navigable for ships of any burden.

The Caspian Sea of Asia is the largest inland body of water on the globe; but its waters are salt, and it is supposed by some to have been formerly connected with the Black Sea and the Sea of Aral. Lake Baikal is the largest body of fresh water on the Eastern Continent, but is less than Lake Superior. Lakes Ladoga and Onega are the largest in Europe.

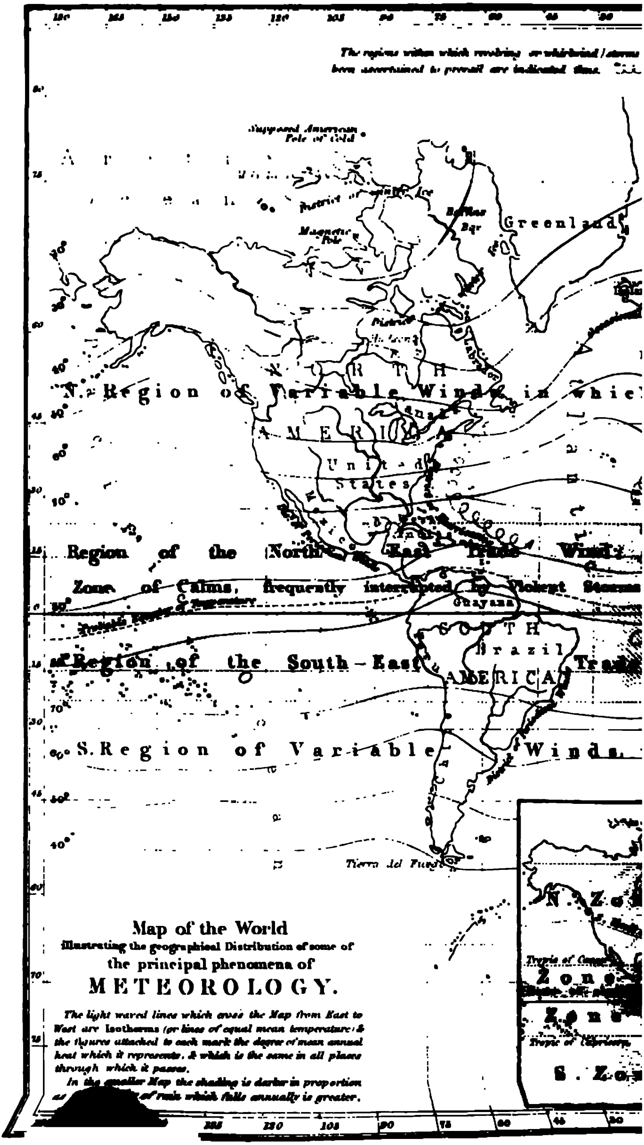
Africa has few lakes. Lake Dembea compares with the Lake of the Woods in size. The Lake of Tchad, in Central Africa, is supposed to be as large as Lake Huron. Sweden, Finland, and the northern declivity of North America, are remarkable for the number occupying deep clefts or basins in the rocks on which these countries are based. The lowlands of Northern Germany, on the south of the Baltic, also abound in lakes, resembling those of flat countries generally.

The depth of mountain lakes is remarkable, compared with that of seas. Thus, while the Baltic Sea is about 120 feet deep, and the North Sea does not generally exceed 400 feet, Lakes Superior, Huron, Michigan, and Geneva, exceed 900, and Lake Constance 1,200 feet deep. Some lakes or inland seas are entirely below the level of the ocean. Thus the Caspian Sea is from 70 to 90 feet lower than the Mediterranean; and the Dead Sea, or Lake of Asphaltites, not less than 1,000 to 1,300 feet below the same level.

From what has here been said, lakes may be classed into four distinct kinds; the first class embraces those small lakes which have no outlet, and receive no running water; some of these appear to be the water-filled craters of extinct volcanoes. The second class consists of those which have an outlet, but receive no running water. The third is the most numerous, and embraces all those which both receive and discharge streams, such as Lake Baikal, and the Canadian lakes—Superior, Michigan, Huron, Erie, and Ontario. The fourth class is the most singular, it comprises all those lakes which receive streams but have no visible outlet.

The water of lakes is generally fresh, and, especially in those which occur in hilly regions, clear and sweet, so as to be capable of supplying the domestic wants of man. But those which belong to the fourth class form a striking exception, as the water of such is almost always *salt*, in some cases to a degree of intensity which greatly exceeds that of the ocean. The Dead Sea, in Palestine, is among the most striking examples of this, the saline particles contained in its water amounting to nearly 25 in every 100.

The utility of the waters which adorn and fertilize the land, and support all that has life, is too obvious to require illustration. We find that even the falls of the streams, which obstruct navigation, are of great value in aiding the labours of man, and that floods, which sometimes produce desolation, are generally very useful, in enriching the soil and increasing the products of the earth. The names and areas of the principal lakes are stated in the list at the lower part of Map 3.

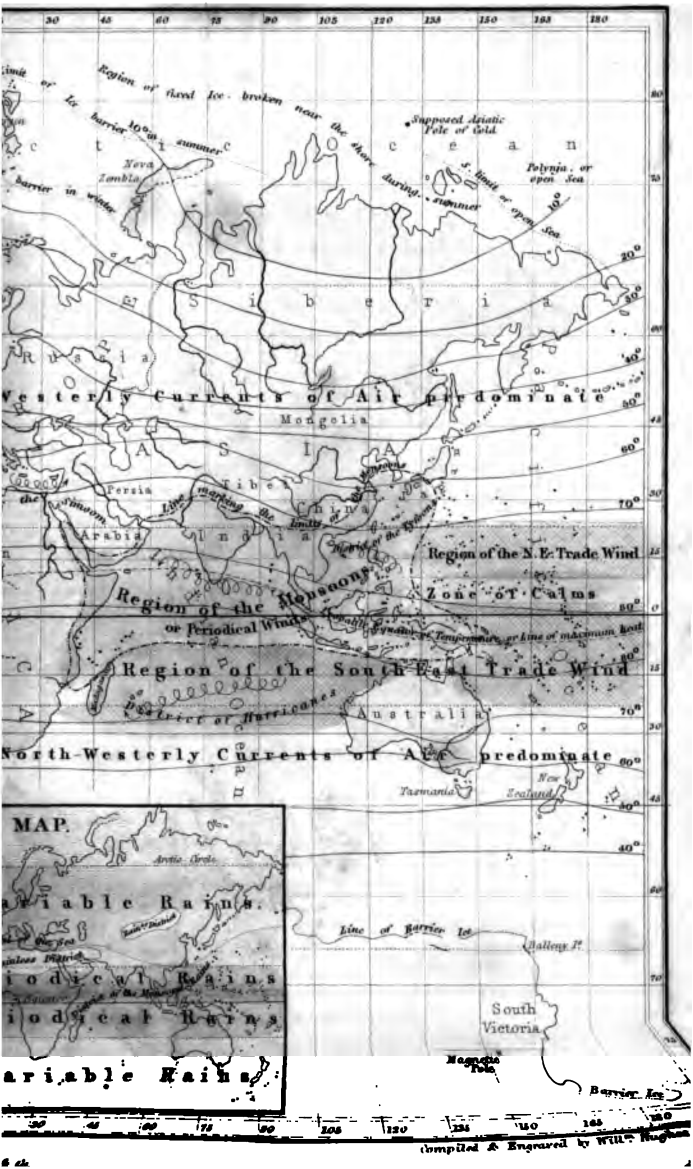

The regions within which revolving or whirlwind (storms
have been ascertained to prevail are indicated thus.
Supposed American Pole of Cold
District of constant Ice
Magnetic Pole
Baffins Bay
Greenland
Labrador
N. Region of Variable Winds in whic
NORTH AMERICA
Canada
United States
Region of the North-East Trade Wind
Zone of Calms, frequently interrupted by Violent Storms
Equator
Guayana
SOUTH AMERICA
Brazil
Region of the South-East Tra
S. Region of Variable Winds
Tierra del Fuego
N. Zo
Tropic of Cancer
Zone
Zone
Tropic of Capricorn
S. Zo

## Map of the World
illustrating the geographical Distribution of some of
the principal phenomena of
# METEOROLOGY.

*The light waved lines which cross the Map from East to West are Isotherms (or lines of equal mean temperature) & the figures attached to each mark the degree of mean annual heat which it represents, & which is the same in all places through which it passes.*

*In the smaller Map the shading is darker in proportion as [illegible] of rain which falls annually is greater.*

Lo



Compiled & Engraved by Will^m. Hughes

# CHAPTER X.

## MAP IV.

### METEOROLOGICAL PHENOMENA.

### I. *The Atmosphere.*

THE atmosphere is that thin fluid which surrounds the earth on every side, and accompanies it in its diurnal revolution about its axis and its annual motion round the sun. Being lighter than either land or water, it rises above them; but it is retained by the power of gravity, and held close to the earth's surface for the use of man and the whole animate and inanimate creation.

The atmosphere is composed principally of two different sorts of gases, termed *oxygen* and *nitrogen*. *Aqueous vapour* is also present in it, and about 10 parts of carbonic acid gas in every 10,000 of atmospheric air. It is an ascertained fact, that while animals extract from the atmosphere the principle called oxygen and return to it carbonic acid, plants do exactly the opposite: so wonderful is the provision for keeping up the purity of this upper and all-embracing ocean. All animal and vegetable life is dependent upon the atmosphere, and man is equally dependent upon it. It supplies to the lungs the oxygen which purifies the blood, and is the food of common fire, and necessary to the support of flame. It diffuses solar light and heat, and is the vehicle of smell and of sound: the stillness of death would reign throughout universal nature were it not for the atmosphere. Its relative proportions are 21 parts of oxygen and 79 of nitrogen, and these proportions are preserved throughout the globe we inhabit; a small proportion of carbonic acid also enters into its composition, and there is always present in it more or less aqueous vapour, which descends in the form of rain and dew to fructify and nourish the earth.

The height of the atmosphere above the surface of the earth we have no means of accurately ascertaining, but we know that at the height of about 45 miles it ceases to refract the rays of light. It is also known to exert a pressure of about 15 pounds upon every square inch of the earth's surface. When we consider the enormous weight of this medium, which contains the elements of life and destruction, and enfolds the earth as a mantle, we are astounded at its immensity; it is expressed by the sum of five quadrillions two hundred and eighty-seven trillions three hundred and fifty billions of tons.

This vast aëreal ocean, at the bottom of which we live, is *elastic*, *invisible*, *transparent*, *subtile*, *expansive*, and *weighty*. It is owing to some of these properties that currents are produced in it, known by the name of *winds*, and which we have now to consider.

### II. *Winds.—Causes of Winds.*

When the equilibrum of the atmosphere is destroyed by changes of temperature in different portions of it—by an increase or diminution of the quantity of water it holds in a state of vapour—or, in short, by anything which causes it to contract or expand, a rush of air then takes place towards the spot where the balance has been destroyed: this motion of the air is called *wind.*

It is well known that heat expands several bodies into which it enters, particularly the metals, thus an iron rod measured at red heat is thicker and longer than when it is perfectly cold. The same holds good of air; it expands, and because it is thinner when warm than when cold (that is, because there is less air in an equal space when it is warm than when it is cold), it is therefore lighter, and rises through the colder air; but the cold air, being heavier, falls to the bottom, and, with a tendency to restore equilibrium, flows in to supply the place of the rarefied air, to be subjected in turn to like heating influences, and to form an ascending current.

Solar heat is the principal agent in producing winds. When a portion of the earth's surface is heated by the solar rays to a higher temperature than the surrounding regions, the column of air resting upon it expands and rises until it reaches a stratum of the atmosphere of lower temperature and greater density than itself, upon which it floats like oil on the surface of water, and spreading out in all directions, produces winds which blow from the hot towards the colder countries. While matters are thus going on in the upper regions of the atmosphere, the equilibrium is also destroyed at the earth's surface. The surrounding heavier air, moving in the direction of the least resistance, rushes into the space which is occupied by extremely rarefied air.

Hence, if two neighbouring regions are unequally heated, there is produced in the upper strata of the atmosphere a wind blowing from the hotter to the colder region; and at the surface of the soil a contrary current.

Now this is precisely what is going on in the equatorial regions. The atmosphere there, being rarefied, ascends in a continuous stream, leaving a space occupied by very thin air, into which the colder and heavier air, from the north and south, rushes with great force and constancy to restore equilibrium. These winds, in passing from high latitudes, where the rotatory motion of the earth's surface is less, to where it is greatest (the air at the poles only turning upon itself, while the air at the equator speeds on through more than 1,000 miles an hour), apparently do not at once acquire this new velocity, and as the earth glides away, as it were, they seem to "lag or hang back," and instead of being north and south winds, as they would if the earth did not revolve, they become *north-east* and *south-east* winds.

As they approach the equator, they acquire a more easterly direction; these winds are known to sailors as the *Trade Winds.*

### III. *Velocity of the Wind.*

The following Table exhibits the results of experiments made by Mr. Smeaton, the celebrated engineer:—

VELOCITY of the WIND.

| Miles per Hour. | Feet per Second. | Perpendicular Force on One Square Foot, in Avoirdupoise Pounds and Parts. | Characteristics. |
|---|---|---|---|
| 1 | 1·47 | ·005 | Hardly perceptible. |
| 2 | 2·93 | ·020 | Just perceptible. |
| 3 | 4·4 | ·044 | |
| 4 | 5·87 | ·079 | Gentle, pleasant wind. |
| 5 | 7·33 | ·123 | |
| 10 | 14·67 | ·492 | Brisk wind. |
| 15 | 22· | 1·107 | |
| 20 | 29·34 | 1·968 | Very brisk wind. |
| 25 | 36·37 | 3·075 | |
| 30 | 44·01 | 4·429 | High wind. |
| 35 | 51·34 | 6·027 | |
| 40 | 58·68 | 7·873 | Very high wind. |
| 45 | 66·01 | 9·963 | |
| 50 | 73·35 | 12·300 | Storm. |
| 60 | 88·02 | 17·715 | Great storm. |
| 80 | 117·36 | 31·490 | Hurricane. |
| 100 | 147·7 | 49·200 | Hurricane carrying trees and buildings before it. |

The velocity of the wind is very sensible, and is estimated for the most part by the force it exerts upon our own bodies. An instrument called the *anemometer* has been constructed, which registers the force and direction of the winds. According to the rapidity with which they move, they are divided into slight breeze, brisk breeze, fresh breeze, strong gale, storm, and tempest. The term *hurricane* is applied to those violent storms which occur within the tropics.

Winds may be divided into three classes,—*Variable Permanent*, and *Periodical.*

### IV. *Variable Winds.*

These, as their name indicates, are altogether irregular as to time, direction, and force; they prevail in mean and high latitudes (see Map), and seldom continue blowing for many days. We are not sufficiently acquainted with the causes that produce these partial and ever-fluctuating aërial currents; but when we reflect that the land is hotter in summer and colder in winter, we are led to conclude that sea-winds should predominate in summer and land-winds in winter: now this conclusion is correct. *Franklin* long ago observed in North America, that in summer the winds came from the south and in winter from the north; and from numerous observations made in different parts of Europe, the following laws have been established in regard to this continent.

In *winter*, the direction of the wind is principally from the south, its force being greatest in January.

In *spring*, east winds are common at certain places in March, and at other places in April.

In *summer*, especially in July, the winds blow chiefly from the west; and in *autumn* the south winds more frequently blow, particularly in October.

The sun's presence in either hemisphere has great influence upon the prevailing westerly winds in high latitudes; in the Northern Atlantic Ocean the wind generally inclines to west-south-west in the summer months; and in winter, almost constantly to west-north-west between the coasts of Newfoundland and Ireland. In the British Channel easterly winds often prevail in February, March, April, and part of May; during the other months, westerly winds prevail greatly.

On the north-west coast of America south-westerly winds prevail in the summer months; and northerly winds during winter.

In the southern hemisphere, during the summer months, when the sun is near the tropic of Capricorn, the winds are sometimes very variable, but prevail at west and west-north-west. In the winter months they blow mostly from west-south-west and west, and sometimes from south or south-east. Westerly winds prevail off the Cape of Good Hope, Cape Horn, and Cape Van Diemen, particularly when the sun is near the tropic of Cancer; but on the western coasts which form these promontories, the wind frequently prevails from the southward, when it is blowing strong from the westward off their extremities. And south-easterly or southerly winds are *generally* found to prevail more than any other, in February, March, and part of April, in the vicinity of those headlands.

Colonel Reid, speaking of storms in high latitudes, says, "It has been shown that the hurricanes which originate within the tropics, increase in diameter and diminish in force as they proceed towards the poles; and as the meridians approach each other, the gales may become huddled together. They may, therefore, frequently neutralize each other and become irregular. Their force, too, may often fall off, until the strength of the wind on that side of the circle where it blows from east is unable to reverse the regular westerly atmospheric current, and to convert it into a temporary easterly gale; and this may be the reason why easterly storms are less frequent in both hemispheres in the latitudes within which Great Britain is situated."—*Law of Storms.*

There is a certain class of variable winds known to possess peculiar properties, such as the hot winds felt on the northern coast of Africa, in Persia, India, and China, the cold winds of Siberia, the pestilential simoom or samiel of Africa, Arabia, and Mesopotamia, &c. When winds come from distant places, they partake of the properties by which those regions are characterised; thus the west winds with us, that blow from the Atlantic, are more moist than the east, which sweep over the continent. The north-east wind also is very cold, especially in spring. Variable winds of this nature may be subdivided into cold and hot winds.

*Cold Winds.*—In the south of Europe the north winds are of great violence and severity, the extremes of temperature existing between the Mediterranean and the glacier-covered Alps giving rise to aërial currents of frightful rapidity. When the effect of these gusts is combined with a general north wind, there is produced a north-east wind of extraordinary violence. In Istria and Dalmatia, where it is called the bora, it has been known to overturn horses and ploughs. A similar wind, named the *mistral*, at times sweeps up the valley of the Rhone; and in Spain, a north wind, called the *gallego*, is of a very formidable character.

*Hot Winds.*—Large deserts and plains, covered with little vegetation, engender very hot winds: these winds, which are of a noxious character, prevail in the vast deserts of Asia and Africa, where they show themselves in all their force. The arid wastes of Nubia, and of Arabia, Persia, and other parts of Asia, are visited by a burning wind peculiar to the desert. In Arabia it is called *samoun*, simoum, sèmoun, from the Arabic *samma*, which signifies at once hot and poisonous. It is also named *samiel*, from *samm*, poison. In Egypt it is called *chamsin* (fifty), because it blows for 50 days, from the end of April until June, at the commencement of the inundation of the Nile. In the western part of the Sahara it is named *Harmattan*, but the term *samoun* is generally employed, translators insisting on the meaning poison, without reflecting that, like children, uncivilized people call everything *poison* which is disagreeable or dangerous.

*The Simoom* is announced by the troubled appearance of the horizon; afterwards the sky becomes obscured, and the sun loses its brilliancy,—paler than the moon, its light no longer projects a shadow; the green of the trees appears of a dirty blue, the birds are restless, and the affrighted animals wander in all directions.

The rapid evaporation occurring at the surface of the human body dries the skin, inflames the throat, accelerates respiration, and causes a violent thirst. The water contained in the skin evaporates, and the caravan is a prey to all the horrors of thirst. It is thus that, since the expedition of Cambyses, more than one caravan has perished in this desert: but we must class among Arab tales those histories of pestilential winds, the contact of which causes death, and which, like a cannon-ball, traverse a troop and choose out their victims. When the Arabs cover their face, it is that the sand may not penetrate either into the eyes or into the mouth: for the same reason it is that camels turn their heads from the side opposed to the wind; they never perform this manœuvre unless sand is in the air.*

"In June, 1813," says Burckhardt, "in going from Siout to Esné, I was surprised by the simoom in the plain which separates Farschiout from Berdys. When the wind arose I was alone, mounted on my dromedary, and at a distance from every tree and habitation. I endeavoured to protect my face by wrapping it in a handkerchief. Meanwhile, the dromedary, into whose eyes the wind drove the sand, became restless, commenced galloping, and caused me to lose the stirrups. I remained lying on the earth without moving from the spot, for I could not see to a distance of ten metres, and I wrapped myself up in my clothes until the wind had abated. I then went to search after my dromedary, which I found at a very great distance, lying down near a bush that protected his head against the sand raised by the wind."

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* Kaemtz on 'The Physical Properties of Winds.'

Volney gives the following complete account of the simoom and its effects:—

"Travellers have mentioned these winds under the name of poisonous winds, or, more correctly, hot winds of the desert. Such, in fact, is their quality; and their heat is sometimes so excessive that it is difficult to form an idea of their violence without having experienced it, but it may be compared to the heat of a large oven at the moment of drawing out the bread. When these winds begin to blow, the atmosphere assumes an alarming aspect. The sky, at other times so clear in this climate, becomes dark and heavy; the sun loses its splendour, and appears of a violet colour. The air is not cloudy, but grey and thick, and is, in fact, filled with an extremely subtle dust, that penetrates everywhere. This wind, always light and rapid, is not at first remarkably hot, but it increases in heat in proportion as it continues. All animated bodies soon discover it by the change it produces in them. The lungs, which a too rarefied air no longer expands, are contracted and become painful. Respiration is short and difficult, the skin parched and dry, and the body consumed by an internal heat. In vain is recourse had to large draughts of water; nothing can restore perspiration. In vain is coolness sought for; all bodies in which it is usual to find it deceive the hand that touches them. Marble, iron, water, notwithstanding the sun no longer appears, are hot. The streets are deserted, and the dead silence of night reigns everywhere. The inhabitants of towns and villages shut themselves up in their houses, and those of the desert in their tents, or in pits they dig in the earth, where they wait the termination of this destructive heat. It usually lasts three days, but if it exceeds that time it becomes insupportable. Woe to the traveller whom this wind surprises remote from shelter! he must suffer all its dreadful consequences, which sometimes are mortal. The danger is most imminent when it blows in squalls, for then the rapidity of the wind increases the heat to such a degree as to cause sudden death. This death is a real suffocation: the lungs being empty are convulsed, the circulation disordered, and the whole mass of blood driven by the heat towards the head and breast, whence that hæmorrhage at the nose and mouth which happens after death. This wind is especially fatal to persons of a plethoric habit, and those in whom fatigue has destroyed the tone of the muscles and vessels. The corpse remains a long time warm, swells, turns blue, and is easily separated, all of which are signs of that putrid fermentation which takes place when the humours become stagnant. These accidents are to be avoided by stopping the nose and mouth with handkerchiefs: an efficacious method is also that practised by the camels, who bury their noses in the sand and keep them there till the squall is over. Another quality of this wind is its extreme aridity, which is such, that water sprinkled upon the floor evaporates in a few minutes. By this extreme dryness it withers and strips all the plants, and, by exhaling too suddenly the emanations from animal bodies, crisps the skin, closes the pores, and causes that feverish heat which is the invariable effect of suppressed perspiration."

*The Harmattan* blows from the interior of the Great Desert of Sahara, from the north-east, over Senegambia and Guinea towards the Atlantic Ocean, extending along a coast-line of 2,000 miles. Extreme dryness is the property of this wind, which continues to blow sometimes only a day or two, at other times for five or six days, and even for a fortnight. All vegetation droops and withers; and should the harmattan blow for several days, the leaves of the lemon, orange, and lime-trees become so parched that they may be readily rubbed to dust: even household furniture cracks, and in many instances flies to pieces. Though this wind is so pernicious in its effects upon vegetable life, yet it is conducive to the health of the human species, by removing humidity from the atmosphere and counteracting its effects after the long rainy season.

*The Sirocco* is a hot south-east wind prevailing in the Mediterranean, in Italy, and Sicily. It is thus described by an English gentleman during his stay at Palermo:—

"On Sunday we had the long-expected sirocco wind, which, although our expectations had been raised pretty high, yet I own greatly exceeded them. Friday and Saturday were uncommonly cool, the mercury never being higher than 72½°; and although the sirocco is said to have set in early on Sunday morning, the air in our apartments, which are very large, with high ceilings, was not in the least affected by it at eight o'clock, when I rose. I opened the door without having any suspicion of such a change; and, indeed, I never was more astonished in my life. The first blast of it on my face felt like the burning steam from the mouth of an oven. I drew back my head and shut the door, calling out to Fullarton that the whole atmosphere was in a flame. However, we ventured to open another door that leads to a cool platform, where we usually walk: this was not exposed to the wind; and here I found the heat much more supportable than I could have expected from the first specimen I had of it at the other door. It felt somewhat like the subterraneous sweating stoves at Naples, but still much hotter. In a few minutes we found every fibre greatly relaxed, and the pores opened to such a degree that we expected soon to be thrown into a profuse sweat. I went to examine the thermometer, and found the air in the room as yet so little affected that it stood only at 73°; the preceding night it was at 72½°. I took it out to the open air, when it immediately rose to 110°, and soon after to 112°; and I am confident that in our old lodgings, or anywhere within the city, it must have risen several degrees higher. The air was thick and heavy, but the barometer was little affected; it had fallen only about a line. The sun did not once appear the whole day, otherwise I am persuaded the heat must have been insupportable. On that side of our platform which is exposed to the wind, it was with difficulty we could bear it for a few minutes. Here I exposed a little pomatum, which was melted down as if I had laid it before the fire. I attempted to take a walk in the street, to see if any creature was stirring, but I found it too much for me, and was glad to get up stairs again. This extraordinary heat continued till three o'clock in the afternoon, when the wind changed at once, almost to the opposite point of the compass. All nature languishes under the influence of this wind; vegetation droops and withers: the Italians suffering from it not less than strangers. When any feeble literary production appears, the strongest phrase of disapprobation they can bestow is, 'It was written in the time of the sirocco.'"

The deserts of Asia and Africa, as we have said before, are the regions in which the hot or burning winds prevail; but in Spain, the *Solano*, a wind which is supposed to arise in the plains of Andalusia, throws the majority of individuals into a condition of peculiar languor. In India, which is covered with a rich vegetation, and in Chile, in Louisiana, and in the great level plains (*Llanos*) of the Orinoco, there are certain local winds of a very elevated temperature.

*Puna Winds.*—In Peru, between the Cordilleras and the Andes, at the height of 12,000 feet, are vast tracts of desolate table-land, known by the name of the *Puna*. These regions are swept, for four months in the year, by a piercingly-cold wind from the snowy peaks of the Cordilleras, which is so extremely dry, and absorbs with such rapidity the moisture of animal bodies, that it prevents putridity. If a mule happens to die upon these plains, it is converted, in the course of a few days, into a mummy; even the entrails being free from the slightest evidence of decay.

According to Prescott, the ancient Peruvians preserved the bodies of their dead for ages, by simply exposing them to the dry, cold, and rarefied atmosphere of the mountains.

### V. *Permanent Winds.*

*The Trade Winds* extend generally from about 28° to 30° on each side of the equator, but their limits vary considerably as the sun is north or south of the equator; their external and internal boundaries are also different in the Atlantic and Indian Oceans. There is usually a considerable space between them, in which light variable winds prevail mostly from the westward, forming in several parts of the globe, near the equator, a kind of monsoon. It may be further remarked, that it is only over the wide ocean that the trade winds can blow uninterruptedly.

Nothing excited the astonishment of the early navigators who ventured into the Atlantic so much as the east wind, which blew regularly within the tropics. The companions of Columbus were terrified when they found themselves gliding on by continuous east winds, which seemed to forewarn them that they should never return to their country. For several centuries the explanation was sought after in vain: at last Halley and Hadley proposed the following theory:—"The regions bordering on the equator are the hottest on the earth, because the sun is at no great distance from their zenith; but, setting out from these zones, the temperature goes on diminishing in proportion as we approach the poles. There is, therefore, formed an upper current from the equator toward the two poles, and a lower one from the poles to the equator.

The air from the poles becomes heated in the neighbourhood of the equator; it ascends and returns anew towards the extremities of the terrestrial axis. On this principle we ought to find a north wind in the northern hemisphere, and a south wind in the southern; but these two directions combine with the motion of the earth from west to east, and there results a N.E. wind in one hemisphere and a S.E. wind in the other. Indeed, as the diameter of the parallel circles continues diminishing in proportion as we recede from the equator, and as all the points situated in the same meridian turn round the axis of the earth in twenty-four hours, it follows that they move with a velocity much greater as they are nearer to the equinoctial line. But the masses of air which flow from the north toward the equator have an acquired velocity less than that of the region toward which they are directed. They, therefore, turn more slowly than do the points situated near the equator, and they oppose to the elevated parts of the surface of the globe a resistance analogous to that of the well-defined N.E. wind. For the same reason, the trade wind of the southern hemisphere blows from the south-east." Or the cause of the trade winds may be explained thus.

The atmosphere partakes of the diurnal motion of the earth, and if there were no disturbing cause acting upon it, might be divided into strata parallel to the plane of the equator, that is perpendicular to the axis of rotation, each having an independent rotary motion, which will of course increase regularly from the poles to the equator. Now the effect of the difference of temperature is to transfer a portion of a more northerly, and therefore slower moving stratum southward, and the earth at this point having a higher velocity, the motion of the surface and the atmosphere above it no longer correspond. All things on the surface partaking of this velocity come against the slower moving stratum which produces the effect of a wind in a contrary direction. Let us suppose a steamer moving eastward at the rate of ten miles an hour, and a westerly wind blowing at the same rate, those on deck would feel a calm, but let the wind die away to, say four miles per hour, and an easterly wind of six miles per hour will be felt against the steamer. The effect is precisely the same as if a person at the equator retaining his velocity of rotation was rapidly transferred northward through the strata of decreasing velocity up to the limit of the perceptible action of the equatorial heat.

On approaching the equator from the parallel of 30° few changes are observed in the direction of the winds; they vary from N.N.E. to N.E. or E.N.E.; and in the neighbourhood of the equator they are E. It is, in fact, at the equator that the motion by the earth's rotation is most rapid, and there it is that the masses of air remain most behindhand, and oppose the greatest resistance; it is near this line, also, that the trade-winds from both hemispheres meet, and as one comes from the N.E., and the other from the S.E., an east wind is the result; as when one ball is met by another it takes a direction intermediate between that of the two balls. The trade-winds of one hemisphere also affect all the directions comprised between E. and N.N.E.

The north-east and south-east trade winds prevail in the open sea, in the Atlantic and Pacific Oceans, and from the great extent of the latter, they generally blow more steadily in it than in the former; and the south-east trade wind in the southern Atlantic Ocean blows more steadily than the north-east trade wind to the northward of the equator where the ocean becomes contracted between Cape de Verde and the northern extremity of the coast of Brazil; but towards the West India Islands, the north-east trade wind generally blows steadily between east and east-north-east.

The south-east trade wind prevails also in the Indian Ocean, from within a few degrees of the east side of Madagascar nearly to the coast of New Holland, between the parallels of 10° and 28° S.; but in this ocean, from lat. 10° S. to the coasts of India, the winds are periodical.

## VI. *Periodical Winds.*

*Monsoons*, from the Persian word *mousum*, or the Malay *moosin*, signifying a *season*, are regular periodical winds, which sweep over the Indian Ocean and the whole of Hindoostan, changing their direction after an interval of about six months, as the sun moves into the northern or southern hemisphere; hence the term *season winds*, or monsoons. These winds, it appears, are a modification of the trade winds, occasioned by the position of the sun in different seasons, the openings in the chain of islands separating the Indian Ocean from the Pacific, the interposition of the Asiatic continent, and the rarefied atmosphere of Africa and Australia.

The south-west monsoon prevails from April to October, between the equator and the tropic of Cancer, and it reaches from the east coast of Africa to the coasts of India, China, and the Philippine Islands; its influence extends sometimes into the Pacific Ocean as far as the Marian Islands, or to about long. 145° E., and it reaches as far north as the Japan Islands. In the same season, a south-south-west monsoon prevails to the southward of the equator in the Mozambique Channel, between the Island of Madagascar and the coast of Africa, which is occasioned by the conformation of the lands on each side of that channel.

The north-east monsoon prevails from October to May, throughout nearly the same space as that mentioned above; but the monsoons are subject to great obstructions from land, and in contracted places, such as Malacca Strait, they are changed into variable winds. Their limits are not everywhere the same, nor do they always shift *exactly* at the same period.

The north-west monsoon prevails between the north-east part of Madagascar and the west coast of New Holland from October to April, and it is generally confined between the equator and 10° or 11° s. lat., but subject to irregularities. This monsoon seldom blows steadily in the open sea, although in December and January it generally prevails, and in these months sometimes extend from lat. 10° or 12° s. across the equator to lat. 2° or 3° N. This is the rainy monsoon to the southward of the equator, and the south-east monsoon is the dry season.

The south-east monsoon predominates from April to October in the space last mentioned, and in some places reaches the equator, when the sun is near the northern tropic; but this monsoon may be considered as an extension of the south-east trade following the sun, and when that luminary returns to the southern tropic it recedes to lat. 10° or 12° s.

The parts where the north-west and south-east monsoon prevails with greatest strength and regularity are in the Java Sea, and from thence eastward to Timor, amongst the Molucca and Banda Islands, and onward to New Guinea.

Westerly winds are sometimes experienced near the equator, in the Pacific Ocean, a great way to the eastward of New Guinea: and also in the Atlantic Ocean, westerly winds at times occur near, or a little to the northward of the equator, forming a counter current to the regular north-east and south-east trade winds which prevail on each side of it.

The periodical change or shifting of the wind is called by sailors "the breaking up of the monsoon." This is accompanied by a dreadful commotion of the elements, and the storms which then prevail are sometimes most disastrous in their consequences.

Mr. Caunter, a resident at Madras, gives the following interesting account of a storm which occurred there during the shifting of these winds: "On the 15th of October the flag-staff was struck, as a signal for all vessels to leave the roads, lest they should be overtaken by the monsoon. On that very morning some premonitory symptoms of the approaching war of elements had appeared. As the house we occupied overlooked the beach, we could behold the setting in of the monsoon in all its grand and terrific sublimity. The wind, with a force which nothing could resist, bent the tufted heads of the tall, slim, cocoa-nut trees almost to the earth, flinging the light sand into the air in eddying vortices, until the rain had either so increased its gravity, or beaten it into a mass, as to prevent the wind from raising it. The pale lightning streamed from the clouds in broad sheets of flame, which appeared to encircle the heavens as if every element had been converted into fire, and the world was on the eve of a general conflagration; whilst the peal which instantly followed was like the explosion of a gunpowder magazine. The heavens seemed to be one vast reservoir of flame, which was propelled from its voluminous bed by some invisible but omnipotent agency, and threatened to fling its fiery ruin upon everything around. In some parts, however, of the pitchy vapour by which the skies were by this time completely overspread, the lightning was seen only occasionally to glimmer in faint streaks of light, as if struggling, but unable, to escape from its prison,—igniting, but too weak to burst, the impervious bosoms of those capacious magazines in which it was at once engendered and pent up. So heavy and continuous was the rain, that scarcely anything save those vivid bursts of light, which nothing could arrest or resist, was perceptible through it. The thunder was so painfully loud that it frequently caused the ear to throb; it seemed as if mines were momentarily springing in the heavens, and I could almost fancy that one of the sublimest fictions of heathen fable was realized at this moment before me, and that I was hearing an assault of the Titans. The surf was raised by the wind and scattered in thin billows of foam over the esplanade, which was completely powdered with the white feathery spray. It extended several hundred yards from the beach; fish upwards of three inches long were found upon the flat roofs of houses in the town during the prevalence of the monsoon, either blown from the sea by the violence of the gales, or taken up in the waterspouts, which are very prevalent in this tempestuous season. When these burst, whatever they contain is frequently borne by the sweeping blast to a considerable distance over-land, and deposited in the most uncongenial situations ; so that now during the violence of these tropical storms, fish are found alive on the tops of houses ; nor is this any longer a matter of surprise to the established resident in India, who sees every year a repetition of this singular phenomenon. During the extreme violence of the storm the heat was occasionally almost beyond endurance, particularly after the first day or two, when the wind would at intervals entirely subside, so that not a breath of air could be felt, and the punka afforded but a partial relief to that distressing sensation which is caused by the oppressive stillness of the air so well known in India."

The monsoons are of great assistance to commerce ; by them a ship is frequently wafted to a distant port, and aided in returning by a monsoon blowing in an opposite direction to that which carried her out.

Another class of periodical winds are—

*Land and Sea Breezes*, which are caused by the unequal heating of the land and sea: the temperature on both is nearly equal, and the air is in a state of equilibrium, a few hours after the sun has risen; but as the sun rises in the heavens the earth becomes more heated than the water, consequently the air above the earth becoming rarefied, ascends and flows towards the sea, which is ascertained by the motion of elevated clouds. The cooler air over the sea now rushes in upon the land, and thus the sea breeze is established in the morning. At the time of the greatest temperature of the day this breeze acquires its greatest force, but towards evening, as the earth gradually gives out its heat, the air above it becomes cool, and at sun-set it has the same temperature as the sea air, and hence there are a few hours of perfect calm. During the night the earth becomes colder than the sea, and the air above it condenses by reason of a diminution of temperature, and rushes from the land towards the sea, causing the *land breeze*.

The hours at which these breezes are felt differ somewhat in different countries and at different seasons. Generally, the breeze from the sea begins to be felt some hours after the sun appears above the horizon ; at first it blows gently, but gradually increases in force and extent until three o'clock in the afternoon : it then decreases, to give place to the land wind, which springs up soon after sun-set. These breezes are particularly developed along the coast of Malabar, where it is said that their influence is felt sixty miles from land. They are also very perceptible in the Mediterranean and in the East and West India Islands. The regular inland breezes experienced in the morning and evening, in some situations, are produced by changes in the density of the atmosphere, effected by the radiating properties of neighbouring snow-clad mountains, marshes, or sandy deserts.

*The Etesian Winds* are periodical winds, which blow from the north-east for about six weeks throughout the Mediterranean, particularly the Levant, where they commence towards the middle of July, about nine in the morning, and continue only throughout the day.

*The Zone of Calms*, represented on the Map, has a breadth of about 6° ; but this varies with the seasons from 9° to 10°. It is frequently interrupted by violent storms.

"When the vessel on its voyage to the south approaches the equator in the midst of the Atlantic Ocean, anxious fear seizes the whole crew. Sooner or later, according to the time of year, the favouring wind which had brought them thus far becomes weaker and weaker; at first it ceases for a little while, and at last drops entirely. Around extends the sea, an endless glassy surface. The ship, hitherto speeding onward with a bird-like flight, lies bound on the crystal fluid. The rays of the sun, falling perpendicularly, glow through and through the narrow space in which the men are enclosed. The deck burns through the soles of the shoes. A stifling vapour fills the cabins. A fortnight has the ruler of the sea lain immoveable in the same spot. The store of water is exhausted. Glowing thirst glues the parched tongue to the palate. Each man looks upon his companions in suffering with the wild, murderous glance of despair.

"The sun sinks below the horizon, the evening sky is illumined by a peculiar coppery redness; and with the advancing night arises a black wall to the eastward; a low, shrill pipe resounds from the distance, from whence a streak of foam advances over the black ocean. The ship sways and rocks upon the irregular waves, but the sail still hangs against the mast, flapping dismally upon the spars. Suddenly the storm bursts over with frightful roar; with a shriek, the sails are torn asunder, and fly in ribbons! A loud crack! a second, and the mainmast goes overboard! By a violent effort the crew succeed in cutting through the remaining ropes, and the ship now flies over the ocean—now borne high upon the backs of the waves—now hurled down into the depths; so that every seam creaks and groans as though it would part asunder. The thunder rolls unceasingly; continuous lightning darts through the agitated atmosphere; the rain falls in streams instead of drops. Ten times the sailors give themselves up for lost, when the quaking bark falls into the trough of the sea, and as many times does it rise over the waves again. At last the storm lulls; single shocks follow, always at longer intervals: the waves become smoother, and when the consoling sun rises in the east, it illuminates the same dreary picture as on the former day. Mirror-like, the endless surface again expands, and in eight days is the store of collected water exhausted; and again the silent spectres creep about and turn murderous looks upon each other. A new storm, and a new calm, and in so frightful alternation, until at last the ship is driven into the region of the peaceful trade wind on the other side of the equator. Hundreds of ships have gone down in storms here; hundreds lost their crews by the most frightful of deaths—that from thirst; and those who have passed the fearful region of calms, turn in earnest worship to heaven with thanks for their new-won life." *

## VII. *Hurricanes.*

The terms *Hurricane*, *Whirlwind*, *Waterspout*, *Landspout*, *Sand-pillar*, *Tornado*, *White-squall*, *Pampero*, &c., have been applied to rotatory movements of the atmosphere in different parts of the world.

*Hurricanes*, or *Cyclones*, are revolving storms which occur in the West Indies and in the Indian Ocean. Of a similar kind are the *Typhoons* in the Chinese Seas. These atmospheric currents are in the nature of vortices or circulating movements participated in by masses of air from 50 to 500 miles in diameter, revolving the more rapidly the nearer the centre, up to a certain distance, or radius, *within which there is a calm.*

The place of this centre of rotation meanwhile advances steadily along a definite line upon the globe, with a velocity varying from 2 to 30 or 40 miles per hour, and pursuing a track which, in some of the hurricane regions, as in the West Indies, has a singular fixity of geographical situation and geometrical form. But the character which it is of most importance to a seaman to know, and the knowledge of which may often save his ship from disaster, as ignorance of it has repeatedly been the cause of catastrophes which might have been avoided, is this, viz., that in the same hemisphere great cyclones *always* revolve *the same way* (so far at least as our present information extends), but that this direction is opposite in opposite hemispheres. In the northern hemisphere their rotation is *retrograde*, *i. e.*, contrary to the motion of the hands of a watch laid face upwards, or in conformity with the motion of the hand in *unscrewing* a screw. In the southern their rotation is *direct*, conformable to the hands of a watch, or to the motion of the hand in screwing *in* a screw to a horizontal board. From this general fact can be ascertained, at any given moment, *the bearing of the centre of the vortex*, which is the point of extreme danger, by reason of the fury of the wind in its vicinity, its sudden reversal, and the terrible sea which prevails there.*

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* Schleiden's 'Lecture about the Weather.'

It was formerly supposed that hurricanes were violent winds, sweeping with immense velocity in a rectilinear direction; but their true nature was first clearly established by Mr. Redfield of New York, in a series of articles in Silliman's "American Journal of Science:" and afterwards by Colonel Reid, of the Corps of Royal Engineers, in his admirable works, "The Law of Storms" and "Storms and Variable Winds;" also by Mr. Piddington, in his work called "The Sailor's Hornbook for the Law of Storms"—"Works," says Sir John Herschel, "which no navigator should go to sea unprovided with."

*Typhoons* are hurricanes which occur once in three or four years in the Chinese Seas, between the lat. of 10° and 30° N. One of these dreadful storms, which visited Hong Kong in July, 1841, is thus described by W. H. Hall, Commander of H.M.S. *Nemesis*, then lying in harbour at the above place.

"For some days previously large black masses of clouds appeared to settle upon the hills on either side; the atmosphere was extremely sultry and oppressive; the most vivid lightning shot incessantly along the dense threatening clouds, and looked the more brilliant, because the phenomena were always most remarkable at night, while during the day the threatening appearances were moderated considerably, and sometimes almost entirely disappeared. The vibrations of the mercury in the barometer were constant and rapid; and although it occasionally rose, still the improvement was only temporary, and upon the average it continued to fall. A typhoon was therefore confidently predicted; and the more so, because none had occurred for several years. Between seven and eight o'clock in the morning the wind was blowing hard from the northward, or directly upon the shore of Hong Kong, and continued to increase in heavy squalls hour after hour. Ships were already beginning to drive, and the work of destruction had commenced on every side; the Chinese junks and boats were blown about in all directions, and one of them was seen to founder with all hands on board. The fine basin of Hong Kong was gradually covered with scattered wrecks of the war of elements; planks, spars, broken boats, and human beings clinging hopelessly for succour to every treacherous log, were tossed about on every side; the wind howled, and tore away everything before it, literally sweeping the face of the waters. From half-past ten until two the hurricane was at its highest, the barometer at this time having descended to nearly 28° 50′, according to some, but on board the *Nemesis* it was never lower than 28° 59′. The air was filled with spray and salt, so that it was impossible to see anything that was not almost close at hand; the wind roared and howled fearfully, so that it was impossible to hear a word that was said. Ships were now drifting foul of each other in all directions; masts were being cut away; and, from the strength of the wind forcing the sea high upon the shore, several ships were driven high and dry. The native Chinese were all distracted, imploring their gods in vain for help. Such an awful scene of destruction and ruin is rarely witnessed, and almost every one was so busy in thinking of his own safety as to be unable to render assistance to any one else. Hundreds of Chinese were drowned; and occasionally a whole family, children and all, floated past the ships, clinging, in apparent apathy (perhaps under the influence of opium), to the last remnants of their shattered boats, which soon tumbled to pieces, and left them to their fate."

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* Sir John Herschel in the article Meteorology, Admiralty 'Manual,' &c.

Within the limits of the typhoons, the Philippine Islands are visited with storms of a dreadful nature, "which devastate fields, uproot the largest trees, overturn houses, and drive the shipping on shore."

The barometer is a certain indicator of an approaching storm in tropical seas. Its use in such cases is thus beautifully described by the celebrated Dr. Arnott, from observations of the instrument made during a hurricane of which he was himself an eye-witness.

"To the husbandman, the barometer is of considerable use, by aiding and correcting the prognostics of the weather which he draws from local signs familiar to him; but its great use as a weather-glass seems to be to the mariner, who roams over the whole ocean, and is often under skies and climates altogether new to him. The watchful captain of the present day, trusting to this extraordinary monitor, is frequently enabled to take in sail and to make ready for the storm, where, in former times, the dreadful visitation would have fallen upon him unprepared. It was in a southern latitude; the sun had just set with placid appearance, closing a beautiful afternoon, and the usual mirth of the evening watch was proceeding, when the captain's order came to prepare with all haste for a storm. The barometer had begun to fall with appalling rapidity. As yet, the oldest sailors had not perceived even a threatening in the sky, and were surprised at the extent and hurry of the preparations; but the required measures were not completed, when a more awful hurricane burst upon them than the most experienced had ever braved. Nothing could withstand it; the sails, already furled and closely bound to the yards, were riven away in tatters; even the yards and masts themselves were in great part disabled; and at one time the whole had nearly fallen by the board. Such, for a few hours, was the mingled roar of the hurricane among the rigging, of the waves around, and of the incessant peals of thunder, that no human voice could be heard, and, amidst the general consternation, even the trumpet sounded in vain. In that awful night, but for the little tube of mercury which had given the warning, neither the strength of the noble ship, nor the skill and energies of the commander, could have availed anything, and not a man would have escaped to tell the tale. On the following morning the wind was again at rest; but the ship lay upon the yet heaving waves, an unsightly wreck."*

## VIII. *Evaporation.*

It has been proved by several experiments that water evaporates at all temperatures. If at any season we expose water to the air in an open vessel, the water will in time evaporate and entirely disappear. Even ice sends off vapour; for if a piece of ice be placed in a balance-pan, at a low temperature, it will be found gradually to lose weight. Evaporation is caused chiefly by the solar action on the surface of the sea, of rivers, of lakes, and moist ground; the invisible vapour, rising into the air, mixes with it, until it is condensed and assumes the form of *mist*, *fog*, or *clouds*, or falls in the shape of *rain*, *snow*, or *hail*. A determinate volume of air, a cubic foot, for example, at a given temperature, has the property of receiving a certain quantity of vapour, of water in an invisible state, or, as we call it, *humidity*. When it contains all the humidity it is capable of receiving, it is said to be *saturated*. If we increase the temperature, it will be able to hold more; if, on the contrary, we lower the temperature, we diminish its capacity for vapour, and in the given case a part of the vapour would be condensed and deposited in small drops of rain along the outside of the vessel. The moist air here is like a sponge filled with water; reduce its volume by pressure, there will run out a certain quantity of water; in the air laden with moisture the diminution of the temperature takes the place of pressure. The amount of water thus changed into vapour is very large indeed: from experiments made by Mr. Glaisher, of the Royal Observatory at Greenwich, it appears that the vapour which has passed into the atmosphere in one year, if reconverted into water, would cover the surface from which the evaporation took place to a height of 30 inches.

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* 'Elements of Physics.'

Assuming that this is about the annual quantity, and that the surface of all the waters on the earth is 130 millions of miles, then water to the amount of 62,000 cubic miles, would be annually changed into vapour.

*Dew-point.*—If a mass of air be gradually cooled, it will at last descend to a degree of temperature at which it becomes saturated by the aqueous vapour contained in it. The degree of temperature indicated by the thermometer when dew begins to be deposited, is called the *dew-point*, and this point varies with the degree of humidity of the atmosphere.

## IX. *Dew and White-frost.*

When aqueous vapour descends during the night, in the form of drops spread on the surface of plants and other bodies, it obtains the name of *dew*; but if the temperature is very low it appears in the state of *white-frost*. This kind of precipitation more frequently takes place when the sky is clear. Dr. Wells has shown, from a series of experiments, that dew falls for the most part during calm and serene nights, and that it is deposited in preference on bodies not protected by shelter;

hence there falls more dew in the open country than in cities, where houses conceal a portion of the sky. Some bodies are covered with dew sooner than others: plants are more wetted than the earth; sand sooner than a trodden soil; glass sooner than metals; chips sooner than a piece of wood.

The following is Dr. Wells's opinion on the formation of dew.

Dew is the effect of the fall of temperature in the strata of air in contact with the soil. When the latter is heated during the day, the vapours rise; and when towards evening the force of the ascending current begins to diminish, they fall again toward the earth, without the air being saturated. After sunset, and when the weather is calm and the sky serene, the soil radiates, and its temperature descends several degrees below that of the contiguous stratum of air of a few inches in thickness. Then the phenomenon of the precipitation of vapour on a cold glass, when brought into a heated room, takes place on a grand scale, and the grass is covered with dew. This fall of temperature always precedes the formation of dew. The more notable it is, the more abundant is the dew for equal quantities of vapour of water contained in the air. Agriculturists also very well know that nights with heavy dews are very cold; but this cold is the cause and not the effect of the dew. Everything which opposes radiation (a screen either above or beside the object, for instance) prevents the formation of dew. Plants placed beneath a tree are much less wetted than others. This cooling taking place chiefly in the neighbourhood of the soil, we can conceive that objects are less wetted by dew as they are farther from the earth. Everything proves that an elevation of a few inches above the surface of the soil is quite sufficient to produce great difference. Radiation having but little intensity when the sky is clouded, there is then no dew. It is the same when there is wind; for then the cold strata of air, that are in contact with the soil, are constantly replaced and driven away by others, whose temperature is higher.

All circumstances that favour radiation equally contribute to the formation of dew. A body that is a good radiator, and a bad conductor of heat, will therefore be covered with a very abundant dew. Thus, glass becomes wet sooner than the metals; organised bodies are wetted more quickly than glass, especially when they are in small fragments; because as the heat passes with difficulty from one to the other, that which is lost is not replaced by that which is transmitted from the interior to the surface of the body. Thus, locks of wool are very well suited to these experiments, and become covered with a very abundant dew.

The moister the air is, all other things being equal, the more considerable is the quantity of dew that falls in a given time. Thus it is entirely wanting in arid deserts, notwithstanding the intensity of nocturnal radiation. In our own country nights with abundant dews may be considered as foretelling rain, for they prove that the air contains a great quantity of the vapour of water, and that it is near the point of saturation.

*White-frost* is produced under the same circumstances as dew. While at a few yards above the earth the air is several degrees above the freezing point, the soil is cooled by radiation, and the vapour is congealed in the form of beautiful crystals. This cooling is very hurtful to vegetation; and during the serene nights of spring the products of the kitchen garden are frequently killed by the cold. Here, again, all circumstances that oppose radiation prevent the cooling. Vegetables sheltered by trees suffer less than those that are not so protected. A thin covering of cloth or of straw preserves plants; and the vine has often been prevented from being frozen by lighting fires that give much smoke.

In like manner, as under the name of dew are comprised all the drops of water that remain attached to the leaves of plants, so also under that of hoar-frost are comprised the aqueous precipitations which assume the form of snow. These precipitations may be formed in different ways. When south winds succeed to continuous cold, and the thermometer rises almost to freezing-point, vapours are precipitated in the solid form; stone buildings are quite white, and the branches of trees are covered with beautiful crystals. This form of white frost, which is observed in our climates every winter, is very frequent in the Polar regions during the winter season; the rigging of ships is then adorned with sparkling fringes and regular crystallisation, which sailors have called *beards*.

## X. *Fogs*.

Fogs are masses of aqueous vapour, more or less dense, which rest immediately on the surface of the earth, or cling to the sides of mountains. When they remain suspended at a certain height in the atmosphere they are called clouds.

When fog becomes visible anywhere it is because the air is saturated with moisture. In countries where the soil is moist and hot, and the air moist and cold, thick and freq [illegible] may be expected. This is the case in England, the coasts of which are washed by a sea at an elevated temperature. The same is the case with the seas which lie around Newfoundland, where the gulf stream, which flows from the south, has a higher temperature than the air. In London, fogs have sometimes an extraordinary density and dark colour; this probably is owing to the great admixture of smoke with the aqueous vapour. Fogs cannot possibly form when the air is very dry, for this reason, they are never observed in deserts. In the interior of large continents, and particularly in the interior of Asia and Africa, they only form in the neighbourhood of rivers and lakes.

## XI. *Clouds.*

Clouds are masses of condensed vapour suspended in the atmosphere: they are of the greatest importance to the earth, since they are the grand reservoir of the rains which descend and refresh the ground, and of the snows which clothe and keep it warm in winter. They also serve as a screen to protect the earth from the intense rays of the sun, and as a vehicle for the electric fluid.

The height of clouds varies with the seasons, being much greater in summer than in winter. In certain countries they regularly form and disperse at particular seasons, and are often the precursors of wind, rain, or storms. Forced by the winds to ascend along the sides of mountains, they are uplifted into the colder regions of the atmosphere: they feel the pressure of the air, which is less there, and the expansion of the gases composing them increases the cooling; the air loses its capacity for holding the same quantity of vapours as before. The latter are condensed into clouds, which crown the summits of the mountains and trail along their sides, and are soon dissolved into abundant rains.

The mountain chains are, then, the great condensers, placed by nature here and there along the continents to take from the winds their moisture to serve as reservoirs for the rain-waters, and to distribute them afterwards as they are needed over the surrounding plains. Their wet and cloudy summits seem to be untiringly occupied with this important work. From their sides flow numberless torrents and rivers, carrying in all directions wealth and life. Every system of mountains becomes the centre of a system of irrigation, of water-courses, which give to its neighbourhood a value of primary importance.

This power of condensation is expressed by the fact, that, in the heights of the mountains there falls more water than on their slopes, and at their bases there falls more than in the neighbouring plains. Further, the sides of the chain exposed to the sea-wind receive a quantity of rain much beyond that which falls on the opposite side; so that the great systems of mountains not only divide the spaces, but separate different, and often opposite climates.

The examples of this action of mountain chains on the condensation of the rains are numerous in nature.

The forms assumed by clouds are so various, that, at first sight, it might seem that all classification would be impossible; they have, notwithstanding, been arranged by Mr. Luke Howard into three original, and four formed by combination; this scheme is now universally adopted:—

1. *Cirrus, or Curl-cloud.*—This cloud is so called, from the Latin word cirrus or curl, because it usually resembles a distended lock of hair. It is distinguished from the other kinds by its fibrous structure, the lightness of its appearance, and the variety of figures it is capable of assuming. After a period of fine weather slender filaments of the cirrus are frequently seen stretching like white lines across the azure sky. Sometimes these threads of clouds are arranged in parallel bands, which in the northern, (wherever observations have been taken,) are either directed from south to north, or from south-west to north-east; at other times they separate, resembling the tail of a horse, a form which is known in Germany by the name of wind-trees. These filaments are also not unfrequently seen crossing each other, and investing the sky with a delicate net-work of gauze-like vapour. One of the most beautiful forms of the cirrus occurs when the fibres curl from each side of a band of light cloud, and the whole appears like the feathered grain of a rich piece of mahogany.

The white colour of the cirrus renders it difficult, in all cases, to detect its peculiar structure; for the eye is dazzled by its excessive light. The cloud may, however, be viewed at leisure, by reflection from a blackened mirror, which diminishes the brightness. The cirrus soars the highest of all clouds. Its altitude, at Halle, in Germany, has frequently been estimated, by Kaemetz, to be not less than 21,300 feet; and, from the observations of ten years, this distinguished meteorologist has been led to believe, that it is entirely composed of snow-flakes. Indeed, the temperature of the elevated regions in which it floats must be often far below the freezing point.

2. *Cumulus, or Strachen-cloud.*—This kind of cloud acquires

its name from the Latin word cumulus or heap; the vapour seeming to be piled or heaped together. It is usually seen in the form of a hemispherical mass resting upon a horizontal base; but at times detached masses gather into one vast cloud upon the horizon, their radiant summits gleaming like the snowy peaks of distant mountains. The cumulus is the cloud of day, and is produced by the ascending currents of warm air, caused by the solar heat. During the fine days of summer, its peculiar figure is most perfect, and its formation and decline occur in the following manner. Although the sun may have arisen in a cloudless sky, a few solitary specks of vapour may be seen towards eight or nine o'clock: these, as the day advances, enlarge from within, become thicker, and accumulate in rounded masses, which continue to increase in number and size, till the hottest part of the day. After this time they gradually lessen, and often entirely vanish, leaving the sky at sunset again perfectly serene.

The cumulus floats low in the morning, but its altitude increases with that of the ascending currents, which attain their highest elevation soon after mid-day; towards evening the currents subside, and the cloud descends. This circumstance has often been remarked by meteorologists, when stationed on elevated mountains. In the morning, the cumulus has been seen beneath them, it enveloped them towards noon, then soared above them for several hours, and descended to the vale at the close of the day. It is not difficult to account for the facts just detailed. The cumulus begins to be formed when the warm currents, in their upward progress, arrive at a temperature so low that they become over-saturated with moisture; and the excess is then condensed into a cloud.

The higher the currents rise, the colder is the atmosphere, generally speaking, and the cloud must necessarily enlarge; but when in the afternoon the strength of the currents abates, the clouds which are buoyed up by their force, sink down into warmer regions of the atmosphere, and are either partially or completely dissolved. The rounded figure of the cumulus is attributed by Saussure to the mode of its formation: for when one fluid flows through another at rest, the outline of the figure assumed by the first will be composed of curved lines. This may be seen by suffering a drop of milk, or ink, to fall into a glass of water; but the shape of a cloud of steam, as it issues from the boiler of a locomotive, presents a far better illustration.

3. *Stratus, or Fall-cloud.*—This cloud derives its name from

the Latin word stratus, or covering; it forms about sunset, increases in density during the night, and disappears at sunrise. It is caused by the vapours which have been exhaled during the heat of the day, but return again to the earth towards the evening, when the temperature has declined, and are then condensed into a sheet of clouds, which stretch along and rest upon the horizon. This class likewise includes those light and spreading mists which gather in meadows and vales in the evening of a warm summer's day, floating like a veil over the surface of the ground, and extending but a short distance above it.

4. *Cirro-Stratus, or Wane-cloud.*—This cloud is so called, because it partakes of the characteristics of the cirrus and stratus; originating usually in the cirrus. It is remarkable for its great length, in proportion to its thickness; but though preserving in the main this peculiarity, it assumes many varieties of form. At one time it consists of a number of parallel strata of vapour, in close proximity, blended together at the middle, but separated at the edges, or it may appear as a streak of vapour, broadest at the middle, and tapering towards either end. A third variety consists of small rows of clouds, parallel to one another, each successive row becoming shorter, from the widest part of the cloud to the extremities. The name of cirro-stratus is also given to that thin, gauze-like cloud, which sometimes overspreads the whole sky, and through which the sun and moon are dimly visible.

5. *Cirro-Cumulus, or Sonder-cloud.*—It not unfrequently happens, that the heavens appear as if sown with little round masses of clouds, lying near to each other, but perfectly separated by intervals of sky. This cloud is the cirro-cumulus, and often arises from a change in the cirrus and cirro-stratus; the strata of the latter being divided across the direction of their length, and the different parts rounding into the cirro-cumulus. Sometimes the reverse occurs, and the cirro-cumulus is seen changing into the cirrus and cirro-stratus. The structure of the cirro-cumulus is not always the same; at one time the masses are very dense and well-rounded; at another their form is irregular, and the sky often presents a curdled appearance, when covered with this cloud. Sometimes the cirro-cumulus is so light and fleecy, that the rays of the sun, as they traverse it, are scarcely dimmed. Humboldt found them even so delicate that he was able to discern through them the spots on the moon. The last two classes of clouds, like the cirrus, float at a very great height.

6. *Cumulo-Stratus, or Twin-cloud.*—The variety of cloud to which this name is given, combines the characteristics of the cumulus and stratus. Its base consists of a horizontal stratum or layer of vapour, from which rise large, overhanging masses of cumulus. Sometimes contiguous cumulus clouds unite, and passing into the state of cumulo-stratus, form groups of immense size. This cloud is seen in perfection upon the approach of a thunder-storm, when the cumulus clouds, driven together by the wind, are piled upon each other, and assume those peculiar forms commonly known by the name of thunder-heads. This modification also frequently arises when the cumulus is pierced by the cirro-stratus, one above the other, passing through the same pile of clouds, which then present successive tiers of the cumulo-stratus.

7. *Nimbus, or Rain-cloud.*—This cloud is so called from the Latin word nimbus, a rainy dark cloud; it possesses no peculiarity of form, but is distinguished by its uniform gray tint and fringed edges. It is usually composed of some of the preceding classes of clouds, so blended together that they cannot be distinguished, and is produced by a change in their structure, the result of an increase in density. The nimbus often originates in the cumulo-stratus, which, as it increases in thickness, frequently assumes a black or bluish tint. In a short time this hue changes to gray, a circumstance which indicates that the nimbus is formed and rain descending.

## XII. *Rain.*

Rain is water which, originally taken up into the atmosphere in the state of vapour, is returned to the earth in the form of liquid drops. When the temperature of the atmosphere diminishes, and the vesicles of vapour become large, many of them unite, and, by reason of their increased gravity, fall: in their descent, should they pass through a very dry stratum of air, they continually evaporate, and reach the earth in small drops or fine rain.

We must not forget that it is to the ocean we owe those beneficent rains which refresh and vivify all nature; those springs which quench our thirst; those streams and rivers which fertilize our valleys and our plains, and serve as highways for the commerce of nations; those lakes which spread so many charms over the countries encompassing their borders. We scarcely dream that if the ocean ceased to send to the continents the supply of water necessary to their daily life, the parched and arid earth would soon see all the organized beings that live upon its surface perish in pain and anguish.

In fact, all the continental waters come to us from the ocean. If they are fresh and sweet, it is because they have passed through the great laboratory of nature by the simple process of distillation.

The sun, the great awakener of life, the king of nature, diffuses his burning rays over the face of the waters. He causes the invisible vapours to rise, which, lighter than the air itself, unceasingly tend to soar into the atmosphere, filling it and constituting within it another aqueous atmosphere. In their ascending movement they encounter the colder layers of the higher regions of the atmosphere, which perform the part of coolers. They are condensed in vesicles, which become visible under the form of clouds and fogs; then, borne along by the wind, whether invisible still, or in the state of clouds, they spread themselves over the continents and fall in abundant rains upon the ground, which they fertilize. All the portion of the atmospheric waters not expended for the benefit of the plants and of the animals, nor carried off anew into the atmosphere by evaporation, returns by the springs and rivers to the ocean, whence it came.

Thus the waters of the ocean, by this ever renewed rotation, spread themselves over the lands; the two elements combine, and become a source of life far richer and much superior to what either could have produced by its own forces alone.

Rain is very unequally distributed over the regions of the globe: generally speaking, it is most abundant in the neighbourhood of the equator, where evaporation is going on most rapidly, and it gradually decreases in quantity as we recede from the equator towards the poles. In some districts beyond the tropics it never rains at all, as in the desert regions of the Old World, including the Sahara, the Arabian and Persian Deserts, and the Great Desert of Gobi or Shamo. In the New World, the shores of Peru and the arid regions of Mexico exhibit a similar character. Besides the "Rainless Regions" shown upon the map, there are other countries in which there is an unusually small amount of rain; and, on the contrary, there are some districts where it constantly rains.

Mr. Darwin thus describes an extraordinary drought which was experienced in the province of Buenos Ayres:—

"During this time so little rain fell that the vegetation, even to the thistles, failed; the brooks were dried up, and the whole country assumed the appearance of a dusty high-road. This was especially the case in the northern part of the province of Buenos Ayres, and the southern part of Santa Fé. Very great numbers of birds, wild animals, cattle, and horses perished from the want of food and water. A man told me that the deer used to come into his court-yard to the well, which he had been obliged to dig to supply his own family with water; and that the partridges had hardly strength to fly away when pursued.

"The lowest estimation of the loss of cattle in the province of Buenos Ayres alone was taken at one million head. A proprietor at San Pedro had previously to these years 20,000 cattle; at the end not one remained. San Pedro is situated in the middle of the finest country, and even now abounds again with animals; yet, during the latter part of the gran seco, live cattle were brought in vessels for the consumption of the inhabitants. The animals, roused from their estancias, and wandering far southward, were mingled together in such multitudes, that a government commission was sent from Buenos Ayres to settle the dispute of the owners. Sir Woodbine Parish informed me of another and very curious source of dispute: the ground being so long dry, such quantities of dust were blown about, that, in this open country, the land-marks became obliterated, and people could not tell the limits of their estates. I was informed by an eye-witness, that the cattle, in herds of thousands, rushed into the Parana, and being exhausted by hunger they were unable to crawl up the muddy banks, and thus were drowned. The arm of the river which runs by San Pedro was so full of putrid carcases, that the master of a vessel told me that the smell rendered it quite impassable. Without doubt, several hundred thousand animals perished in the river; their bodies, when putrid, were seen floating down the stream; and many, in all probability, were deposited in the estuary of the Plata. All the small rivers became highly saline, and this caused the death of vast numbers in particular spots; for when an animal drinks of such water it does not recover. Azara describes the fury of the wild horses on a similar occasion, rushing into the marshes, those which arrived first being overwhelmed and crushed by those which followed. He adds, that more than once he has seen the carcases of upwards of a thousand wild horses thus destroyed. I noticed that the smaller streams in the Pampas were paved with a breccia of bones; but this, probably, is the effect of a gradual increase, rather than of the destruction at *any one period.*

"Subsequently to the drought of 1827 to 1832, a very rainy season followed, which caused great floods. Hence, it is almost certain that some thousands of the skeletons were buried by the deposits of the very next year. What would be the opinion of a geologist, viewing such an enormous collection of bones of all kinds of animals and of all ages, thus embedded in one thick earthy mass? Would he not attribute it to a flood having swept over the surface of the land, rather than to the common order of things?"

Captain Owen, in the account of his surveying voyage, relates a similar effect of drought on the elephants at Benguela, on the west coast of Africa. They invaded the town in a body to get possession of the wells, not being able to procure any water in the country. A desperate battle ensued between the inhabitants (amounting to nearly 3,000) and the animals. It terminated in the defeat of the latter; but not until they had killed one man, and maimed a great number.

### XIII. *Distribution of Rains.*

When a warm and moist wind, the south-west of the Atlantic, for example, setting from the tropics, comes in contact with the colder air of the temperate regions, its temperature is lowered; it can no longer contain as great a quantity of vapour. A portion of its humidity is immediately condensed into clouds, and then falls in rain.

Or the opposite; a wind charged with clouds arises in a warmer and a dryer air, comes, for example, from the Mediterranean to the Sahara, as is the case during three-fourths of the year; the burning air of the desert having a much greater capacity for vapour, dissipates instantly all these clouds, which break up, vanish, and disappoint the excited expectation of the traveller, who hoped for refreshing rains. When the moist winds encounter an elevated obstacle, a high chain of mountains, a plateau—they are forced to ascend their slopes, high into the atmosphere; they find there a colder air, which condenses their vapours, and the rain flows down along the sides; the wind passing over to the other side of the chain, arrives there dry and cold, deprived of all its moisture, and without clouds. The same wind thus brings rain on one side and fair weather on the other. This is what happens every day on the two sides of the Scandinavian mountains.

It is even possible that an ascending current, if very violent, may hurry the abundant vapours of the lower layers to the more elevated layers of the atmosphere. The vapours are afterwards condensed there, and fall back in torrents of rain. Such at least is the explanation which Humboldt gives of the rains of the tropics.

The temperature, the winds, and the rain having an intimate connexion each with the others, and playing alternately the part of cause and effect, the earth, in the point of view now under consideration, is divided, as regards temperature and winds, into two great zones—the one, that of periodical rains, or of the tropical regions; the other, that of continuous rains, or of the temperate regions.

Aided by these preliminary remarks, we are enabled to account for the general phenomena regarding the distribution of rains.

We shall proceed to notice the different rain regions laid down on the small Rain Map, commencing with those regions within the tropics, because a greater regularity is observed there than in higher latitudes.

In the equatorial regions, where the course of temperatures and winds is regular, that of the rains is equally so; and instead of seasons of temperature, which are there unknown, the inhabitants draw the distinguishing line between the dry and the rainy season.

Whenever the trade wind blows with its wonted regularity, the sky preserves a constant serenity and a deep azure blue, especially when the sun is in the opposite hemisphere; the air is dry, and the atmosphere cloudless. But in proportion as the sun approaches the zenith, the trade wind grows irregular, the sky assumes a whitish tint, it becomes overcast, clouds appear, sudden showers, accompanied with fierce storms, ensue. They occur more and more frequently, and turn at length into floods of rain, inundating the earth with torrents of water. The air is at this time so damp that the inhabitants are in an incessant vapour bath. The heat is heavy and stifling, the body becomes dull and enervated: this is the period of those endemical fevers that destroy so great a number of the settlers who had come from the temperate zones. But vegetation puts on a new freshness and vigour; the desert itself becomes animated, and is overspread for a few months with enchanting verdure, which furnishes pasture to thousands of animals. Nevertheless, ere long the sun, in his annual progress, advances to pour down his vertical rays upon those places; the rains diminish, the atmosphere becomes once more serene, the trade wind resumes its regularity, and the heaven shuts its windows once again until the following season. Such is the normal course of the tropical rains. They fall everywhere during the passage of the sun through the zenith. The heat is then so violent, that the ascending current neutralizes the horizontal trade wind. It hurries the vapours to the heights of the atmosphere, and the upper limit of the trade wind, where they are condensed and fall back in a deluge of rain. Now as the sun passes and repasses from one tropic to the other, it follows that there is in most intermediate places a two-fold rainy season, the two periods of rain being more or less closely connected in point of time.

In all places situated within the tropics there is an ascending current of air, which is very powerful in those places having the sun in the zenith; this ascending current draws with it masses of vapour, which condense as soon as they reach a certain stratum of the atmosphere, and are returned in heavy rains to the very regions from which they rise. In this zone the sun almost always rises in a clear sky: about noon isolated clouds appear, which pour out prodigious quantities of rain; these showers are generally accompanied with violent gales. Towards evening the clouds dissipate, and the sun sets in a perfectly clear sky. Since these rains are caused by the direct action of the solar rays, the places upon which they fall change with the declination of the sun. As the sun passes twice a-year over the zenith of places situated within the torrid zone, we find that in tropical regions a very considerable quantity falls twice a-year, and at very near intervals. In countries situated near the equator, where the times of the passage of the zenith are separated by a longer interval, there are two rainy and two dry seasons. In all places where the trade wind blows continually seaward it does not rain, and the sky is always serene, especially when the sun is in the opposite hemisphere: but it frequently rains in the region of calms; for this reason it has been designated upon the Map the "Zone of almost constant precipitation."

On shore, between the tropics, the year is divided into two seasons—the wet and the dry season; during the latter, entire months frequently pass away without a single cloud having been seen in the sky. In many countries the night is almost always serene, in others it rains in the night also, and even more so than in the day; but it is probable that this difference is due to the neighbourhood of large chains of mountains.

The northern limit of the periodical rains is not exactly known. In India the course of the rain is not so regular; it depends entirely on the monsoons. The western coast of the

Deccan, the coast of Malabar, has the season of the rains during the monsoon of the south-west, which brings thither the vapours of the ocean; that is, during the northern summer. It has the dry season during the monsoon of the north-east. During the winter the monsoon of the south-west ascends the slopes of the western Ghauts, and causes in the heights violent storms and very abundant rains. Along the coast of Coromandel, on the contrary, it is the north-east monsoon which conducts the rain, with the vapours of the sea of Bengal, and the south-west monsoon brings the dryness. These two coasts of the peninsula have then their seasons reversed. One has the dry weather when the other has rain, and reciprocally. The table-land of the Deccan partakes of the two characters; the fall of water is more variable, and there are often two periods of abundant rains.

We see here that the relative position of the lands and the seas regulates the seasons.

When the wind that blows from the S. W. is forced to ascend along the flanks of the Ghauts, the vapours condense on their summits, and there are violent storms almost every day. In the interior of the country the rains are rare, and on the eastern coast the sky is serene. The rains are most abundant in July. During the N. E. monsoon, the same succession is noticed on the coast of Coromandel; but the mountains not being so steep, the rains are not so heavy. During this time the sky is perfectly serene on the west coast. The table-land of the Deccan partakes of the climate of the two coasts. The distribution of rain during the season depends on the distance of the different points from the sea. According as they are nearer the western or the eastern coasts, the course of the seasons is analogous to that of the corresponding coast. Some places, situated in the middle of the peninsula, have partial rains throughout the year.

The quantity of water that falls in these countries during the space of a single month is more considerable than that of the whole year with us. In places situated near the sea we may admit that from 75 to 125 inches of water fall during the year. Let us add, that it never rains but in certain months, and only during one or two hours of the day, which renders the contrast still more striking. The drops of water are enormous, very close together, and reach the earth with great violence. But if we penetrate into the interior of countries, or ascend considerable heights, the quantity of rain diminishes. At Seringapatam, in India, and at Bogota, in America, it is hardly greater than that observed in Germany. In Africa, near the equator, the season of rain commences as early as April. Between 10° N. lat. and the tropics, principally in the countries watered by the Senegal, it lasts from the commencement of June to the beginning of November. The evaporation of the water that falls over night so saturates the air with vapours, that articles of clothing, or, in short, anything that is not placed near the fire, becomes moist, and the inhabitants live in an atmosphere of vapour. This is the period of the endemic diseases so fatal to Europeans. The approach of this rainy season is announced by changes in the direction of the winds.

On the western coast of America the rain commences in the early days of March; and at San Blas, in California, it rarely rains before the beginning of June.

Humboldt asserts that in the part of South America, situated on the north of the equator, the sky is perfectly serene from December to February; the wind blows from the E. or E.N.E., the air is dry, and vegetation is leafless. Toward the end of February, and at the commencement of March, the blue of the sky becomes deeper, the hygrometer denotes more moisture in the air, and the leaves of the trees begin to burst forth. A slight curtain of vapour dulls the twinkling of the stars, which is dense towards the zenith, where it is sometimes visible. The trade wind blows less violently, and the air is occasionally calm. Clouds, resembling mountains, gradually collect in the S.S.E., and sometimes traverse the sky with incredible velocity. Toward the end of March lightnings shine in the heavens at the south, and the wind passes for several hours to the W. and W.S.W. The atmospheric electricity becomes stronger, especially at sunset, and this is a certain sign of the approach of the rainy season, which on the banks of the Orinoco begins at the end of April. The sky is troubled, and from its former blue becomes grey. In the afternoon, at the moment when the heat is at its maximum, a storm, accompanied by heavy showers, rises in the plains. At the commencement the clouds and rain are only formed during the burning hours of the afternoon, and disappear toward evening; but in proportion as the season advances, especially when the sun is at the zenith, they both commence, being manifest in the morning; but at the end of the season they again appear in the afternoon.*

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* Humboldt's 'Personal Narrative.'

But the annual quantity of rain received in some localities, and under the influence of certain circumstances, is sometimes much more considerable. At Paramaribo, in Dutch Guiana, it falls to the amount of 229 inches of water, or 19 feet. At St. Louis de Maranhao, in Brazil, 276 inches have been received, or 23 feet. But the greatest quantity ever observed is that of Mahabaleshwar, in the Western Ghauts, south of Bombay, at the height of 4,200 feet, it rises to the enormous number of 302 inches. A layer of 25 feet of water would have been formed by the rain waters if they had not gradually run off.

These results are the more astonishing, as all this water falls in the space of only a few months, and, so to speak, at once. It has been seen to fall at Cayenne 21 inches in a single day. This is nearly as much as falls during the whole year in the northern latitudes. This is the reason why, notwithstanding the abundance of the rains, the number of clear days is much more considerable than in our climates. Even during the rainy season the sun shows himself nearly every day, and many days pass without a single drop of water falling from the atmosphere.

We may conceive the prodigious effect such violent showers must produce upon the rivers. Who does not now understand the secret of the overflowings of the Nile, once so mysterions, and which are due to the circumstance that the region of its sources receives the tropical rains? Floods of 40 feet rise and upwards are frequent at this season in the great rivers of South America; the llanos of the Orinoco are changed into an inland sea. The Amazon inundates the plains through which it flows to a vast distance. The Paraguay forms lagoons, which, like those of Xarayes, are more than 300 miles in length, and ooze away during the dry season.

The quantity of water contained in the tropical atmosphere, in the condition of transparent gas, is always considerable. It is in proportion to the heat, which being always very great augments its capacity to a very high degree. Even under the most serene sky the air is still abundantly provided with it. It is this invisible water which, being absorbed by the plants and taken up by their large leaves, produces the vigorous vegetation, and causes the eternal verdure that fills us with astonishment under a sky devoid of rain, and cloudless during more than half the year; while in our climates, from the failure of rain for a few weeks only, we see all verdure languish, and all the flowers perish for the lack of moisture.

*Extra-tropical Rains.*—The distribution of rains in the temperate regions offers a perfect contrast to that of the tropics. Here, throughout the whole year, the earth is watered by the rains of heaven, although sometimes irregularly. But these are variable, as are the winds and the temperature, and secondary circumstances have much influence on them.

The further we recede from the tropics, the more do we find that this periodical character disappears. But we have few established facts as to the mode in which the transition is made from one region to another. North of the tropics we find winter rains, which doubtless are caused by the meeting of the upper trade winds with the north-eastern. The strife of these gives birth to heavy rain-storms. It is so at Madeira and Lisbon. Yet further north, Italy and some portion of the Mediterranean have spring and autumnal rains, which Dove attributes to the transit of the south-west trade wind before and after the solstice. In Germany, according to the same authority, the same cause produces frequent rains at the period of the solstice, or summer rains, which denote the highest point attained by the trade wind in those latitudes at the greatest declination of the sun towards the north.

But it must be admitted that the general character of the rains of those regions, their periods, and their frequency, appear especially to depend on a thousand geographical features which influence them greatly.

The quantity of water held by the atmosphere of the temperate regions is much smaller than that in the air of the tropics. The vegetation therefore cannot endure the want of rain for any length of time, as I have observed, and the quantity of rain water falling in them is also greatly inferior.

The mean is 34 inches in the Old World, and 39 in temperate America, or 35 for the whole zone.

There are causes, however, to be pointed out hereafter which produce the fall of twice and even thrice that quantity at certain points. The number of fair days is also far smaller; but if these fruitful showers are not granted to us with the same prodigality as in the tropical regions, they are, at least, better distributed throughout the year, in a manner more equal, more economical, and more advantageous to vegetation, and the requirements of all organized beings.

During our summer the greatest quantities of rain fall within the Torrid Zone, while to the north of the tropics it rains more abundantly in winter. On collecting all that is known of the different climates of Europe, three rain regions have been established, viz.:—

First, that of England and the west of France, which extends in a modified form into the interior of the continent.

Second, that of Sweden and Finland.

Third, that of the coast of the Mediterranean.

The differences of these three regions consist in the different directions in which the rainy winds blow, and in the distribution of the quantity of water which falls each year.

In Western Europe the winds partake of the characteristics of the vast ocean on one side, and the immense continent on the other.

The S.W. wind from the Atlantic invariably brings rain to all the countries between the Scandinavian and Spanish peninsulas.

In high latitudes the N.E. and E. are the rain-bearing winds, whilst in South Germany the N.W. is the rainy wind. The S.W. winds, before they arrive at this district, precipitate the waters with which they are charged on the south face of the Alps.

The Atlantic, although the great reservoir of rains for the countries of Western Europe, has but little influence over the climate of countries skirting the north of the Mediterranean. The west winds discharge their moisture upon the mountains of South France, the Pyrenees, and the chains of the Spanish peninsula. The S.W. wind, coming from the equator, prevails at the same time with the south wind, of dry and elevated temperature, which blows from the burning desert of Sahara, giving rise to many local hurricanes. The rainy winds of Southern Europe are greatly modified by the elevated ridges of the Alps and Apennines; their direction, therefore, is not so well understood as those which prevail in other parts of Europe.

Countries, as we have remarked, situated in the vicinity of the sea, receive a larger amount of rain than those inland. It has been ascertained that a great deal more rain falls in the west of Europe than in the central and eastern regions; this result has been arrived at by calculating the number of rainy days in each country, comprising under this denomination all those during which it has rained, whether little or much.

This fact has been deduced from a series of observations, the result of which is exhibited in the subjoined Tables.

RELATIVE QUANTITY of RAIN in EUROPE.

| Places. | Mean Number of Rainy Days per Annum. | Quantity of Rain in Inches. |
|---|---|---|
| England, West Coast - - - - | 152 | 37·5 |
| England, East Coast - - - - | | 25·5 |
| Coast of France and Holland - - | 152 | 26·75 |
| Interior of ditto - - - - - - | 147 | 25·5 |
| Central Germany - - - - - - | 141 | 21·25 |
| Buda - - - - - - - - - | 112 | 18 |
| Petersburgh - - - - - - - | 90 | 17 |

And if we express the annual quantity of rain by 100, we shall find the following number for that which falls in each season.

PROPORTIONAL QUANTITIES of RAIN in EUROPE in different SEASONS.*

| Seasons. | West of England. | Interior of England. | West of France. | East of France. | Germany. | Petersburgh. |
|---|---|---|---|---|---|---|
| Winter - - | 26·4 | 23·0 | 23·4 | 19·5 | 18·2 | 13·6 |
| Spring - - | 19·7 | 20·5 | 18·3 | 23·4 | 21·6 | 19·4 |
| Summer - - | 23·0 | 26·0 | 25·1 | 29·4 | 37·1 | 36·5 |
| Autumn - - | 30·9 | 30·4 | 33·3 | 27·3 | 23·2 | 30·5 |

From this we learn, that while in the west of England the quantity of water that falls in summer is to that which falls in winter as 7 to 8, this relation entirely changes as we penetrate into the continent. On the west coasts of France the quantities of water are very nearly equal. In Germany twice as much water falls in summer as in winter; and at Petersburgh the quantity of rain in winter is only a little more than the third of that which falls in summer. The days of rain follow the same laws; on the west coast of England they are more numerous in winter than in summer, while in the interior of Siberia it rains four times more frequently in summer than in winter.

"Rain-water, though distilled by a natural process, is not absolutely pure; for whether in its descent or in its rise as vapour, it contracts impurities from the substances ever floating about in the atmosphere, and becomes partially impregnated with the mephitic and other gases which it meets in its passage; hence it follows of necessity that rain-water has different qualities, according to the places whence it was first sublimed, and the circumstances of the atmosphere through which it falls, which are different in different places and at different seasons. Thus, the rain which falls in winter is much more pure than that which falls in the other seasons; for in winter few or no exhalations rise from the surface of the soil, in consequence of the want of heat, and absence of those putrefactions and decompositions it engenders. The rains of summer, on the contrary, passing as they fall through an atmosphere loaded with exhalations, dissolve a part of these, particularly the carbonic acid, which they restore to the earth. These summer rains are very beneficial, for they purify the air and stimulate vegetation. The rains of spring and autumn participate, more or less, of the nature of those of summer and winter.

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* Kaemtz's 'Meteorology.'

"Rain acts then always as a dissolvent and a vehicle, and as it derives the elements necessary to vegetation from the air, which is itself modified by the seasons and by the circumstances of the soil, the difference in these must produce corresponding differences in the quality as well as the quantity of the vapours which ascend, and of the rain that falls.

"It may, however, be remarked that the disadvantages of too much rain are greatly modified by the nature of the soil on which it falls. On low and clayey lands the water remains, drowns the roots of plants which rot in it, and gives rise to unwholesome exhalations, producing among the inhabitants of the countries so circumstanced fevers and various other illnesses. On an elevated, light, and sandy soil abundant rain is not attended with the same evil consequences, for it runs off or filters through the ground, and can do no other harm than by laying bare the roots of such plants as grow on highly-inclined surfaces; a disadvantage compensated by a general fertility which such soils, but for abundant rains, would not enjoy.

"Without humidity nothing can live or vegetate; and if countries deprived of rain are not supplied with moisture by copious dews, or irrigated artificially, or by the inundation of rivers, they remain barren and uninhabitable.

"One of the great benefits of rain is the supply of those inexhaustible springs, without which there could be no rivers. When rains are heavy they sometimes cause the rivers to overflow their banks, by which, in certain cases, they cause a great benefit, in others a cruel disaster; but whenever they cause a sudden and extraordinary swell of torrent-rivers, which are the only kind in some countries, they always produce consequences more or less disastrous; Italy is a striking example of this. From the small breadth of this country and the nature of its conformation, descending in rapid slopes on either side the Apennines, the rivers are all torrents, and the inhabitants are exposed to their frequently-repeated ravages. There is one very remarkable phenomenon of rain which is particularly worthy of attention, and for the existence of which we have the authority of Humboldt and of Captain Beechy; it is the fall of rain from a perfectly azure and cloudless sky." *

## XIV. *Snow, Glaciers, Hail.*

*Snow* is nothing more than rain congealed before it falls to the earth; the particles of water are not only congealed, but they are crystallized. Captain Scoresby, during his Arctic voyages, observed nearly a hundred different and regular forms of snow; some were very remarkable, and others extremely beautiful. The limits of the fall of snow at the level of the sea, in the northern hemisphere, are about the parallel of 30° in America, and about 36° in the western parts of the Old World; within this snowy region the whole of Europe is embraced.

Snow performs an important part in the general economy of nature. The snow of winter serves as a mantle to keep the ground warm, and thus protect vegetation from being destroyed by the frost, or by cold biting winds. Accumulated on elevated mountain chains, it affords by its thawing a regular supply to rivers and to the interior reservoirs of the earth, whilst in low latitudes it tempers the heat of warm regions.

*Glaciers.*—On ascending a mountain, we find the air constantly becoming more rarefied, so as to render breathing difficult, and walking laborious, at the same time that the heat constantly diminishes. We also find the snow remaining longer on the tops of high hills, than on the plains below. The peaks of the Himalaya, the Andes, and the Alps, are covered with perpetual snow, at all seasons; and the trees and plants of the low lands cease to grow, at a less elevation. These facts prove to us that the air becomes colder as we rise above the general surface of the earth. As we ascend we gradually pass from the region of cultivated fields to that where trees only will grow, and then to tracts covered only with grass and aromatic plants, which furnish rich pasture for cattle in the summer, and valuable medicinal herbs. Above this is the region of polar mosses; and then, at the height of two miles in latitude 40°, and three and a half miles at the equator, the mountains are clothed with perpetual snow. Animal life becomes almost extinct; and, except the occasional flights of the condor, and a few other birds, all above is the abode af silence and desolation.

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* 'What to Observe,' by J. R. Jackson.

In high valleys and table lands we find a similar change of climate, and the distinction of latitudes and zones is lost. In a few hours, we pass through every climate; and the native of the Torrid Zone may find the plants of every region, from the equator to the poles, in ascending the mountains of his own country. In the summer season, the Alps and other mountains of the Temperate Zone are usually covered with a rich verdure, which pastures vast herds of cattle, almost to the edge of the perpetual snows; and these regions are then occupied by herdsmen, who ascend and descend gradually, according to the season. The fragrance of the aromatic plants and vast fields of flowers can often be perceived for miles below; but the return of autumn renders these pastures deserts of snow. From these causes, the permanent habitations of men are seldom found above the height of 6,500 feet, in the Temperate Zone: and the highest known is the monastery of St. Bernard erected on a pass 8,000 feet in height, to afford shelter and aid to travellers. In the Torrid Zone we find populous cities like Quito, Mexico, and Bogota, at this height. The city of Potosi is 13,350 feet above the sea: its mines are wrought at the height of 16,000 feet; and a shepherd's hut, on the Pass of Arequipa, is more than 15,000 feet in elevation. The highest points yet attained by man are 19,192 feet on Chimborazo by Humboldt, and 19,336 and 19,626 feet on the Himalaya Mountains, by Gerard and Boussingault. The limit of perpetual snow (see page 195), varies with the latitude, and often enables us to estimate the height of a mountain. But we find, not only at this limit, but far below it, *perpetual ice*, sometimes in deep clefts or caves, but especially in the deep valleys of snow-capped mountains. These masses are called *glaciers*, and are *sometimes* seen among the Alps, on the borders of fields *covered with* grain.

Glaciers are produced by the alternate melting and freezing of the snows, during the changes of temperature in the day and the seasons. They occur, therefore, chiefly in the Temperate and Frigid Zones, and are found of the greatest extent and magnificence among the Alps and the Norwegian mountains, and on the coasts of Greenland and the Polar Regions, often covering many square miles in extent. They are also found in the Pyrenees, and the Andes of Patagonia. The Alps, between Mont Blanc and the Tyrol, contain about 400 glaciers, some of which are 15 or 18 miles long, and one is estimated to contain from 80 to 100 square miles. Such glaciers are called ice lakes, as the Mer de Glace, on Mont Blanc. The whole extent of these glaciers is estimated at 1,000 square miles, and their depth varies from 100 to 800 or 1,000 feet.

These vast bodies of ice are formed from the snow which falls and slides into the deep valleys during the winter. At the return of spring, it is partially thawed during the day, and at night frozen into porous ice. The weight of the ice itself, and of the snow above, pushes this mass gradually down the declivity, until it reaches a point so low, that the summer heat melts it faster than it can advance. The glaciers of the Aar advanced 2,200 feet from 1827 to 1836, and 2,400 feet from 1836 to 1840. (Agassiz.) A glacier in the valley of Chamouni advanced 1,048 feet in three years; and others have gradually increased until they have filled up passes, and covered fields once cultivated. In their slow but irresistible progress, they carry with them rocks, woods, and buildings, which stand in their way, and deposit them in a heap of ruins in the valleys.

The surface of glaciers is in some cases regular, and presents the appearance of a field of ice. In others, it is broken, with waves, as if a lake had been congealed in the midst of a storm. In many instances, they are irregular and rugged, sometimes adorned with pyramids and peaks, which seem like the turrets and spires of a city.

A glacier is usually covered on its borders, and sometimes even in the centre, with stones and earth, which have fallen or been torn away from the surrounding declivities. Frequently, a wall of ruins, mingled with ice, is formed upon its edge or along its course, several feet in height, called a *moraine*, whose materials are finally deposited at its base. Beneath the glaciers we find, at all seasons, a stream of water, which flows out from them, often through a cavern of ice of beautiful transparent blue, and forms perennial streams, which preserve their icy coldness for a great distance.

Vast masses frequently break off from the snows and glaciers of lofty mountains, and slide into the valleys below. In Switzerland, travellers, houses, and even villages, are sometimes buried by these bodies of snow and ice, which are called *avalanches*, and which are sometimes brought down by the vibrations of the air, produced by the report of a pistol, or a loud shout.

The same effects which arise from the cold of lofty mountains in the Temperate Zone, are produced by the frosts of the Polar Regions near the level of the ocean. The glaciers often cover the sides of the mountains, as well as fill the valleys, and descend to the sea in walls of ice, from 100 to 1,000 feet in height, and frequently many miles in extent. The avalanches which break off from the polar glaciers fall into the sea with a tremendous crash, and agitation of the waters, and then float away into the ocean, in the fields and islands already described, frequently carrying on their surface large masses of earth and rock.

*Hail* is one of those phenomena upon which there is a great diversity of opinion as to its origin; the general opinion, however, seems to be that it is the result of excessive cold in the atmosphere, produced by sudden changes in the electrical state of the clouds.

True hail is an opaque mass, and has generally the form of a pear or a mushroom; large hailstones are surrounded by a thick coat of ice, and are composed of alternate layers of snow and ice; no one has ever seen hailstones formed entirely of transparent ice. If they are divided through the centre, they are found to be composed of alternate layers of ice and snow, around a white, snowy nucleus, resembling the coats of an onion. The surface is rough, and is sometimes studded with icicles. Hailstones fall at different seasons, and in almost all latitudes. They are of different sizes, from small grains to that of pigeon's eggs, hen's eggs, and even to four inches in diameter.

*Geographical Distribution.*—Hailstones are most frequent in the temperate climes, and rarely occur within the tropics, except in the vicinity of mountains whose summits rise above the limit of perpetual snow. Although by no means common, they are not unknown in the high northern latitudes. Simpson, on the 12th of August, 1839, was exposed in the straits of Boothia, in lat 68° 32′ N., to a tremendous thunder-storm, accompanied with torrents of rain and heavy showers of hail. It is mostly in summer, and usually at the hottest part of the day, that hail is observed to fall. Scarcely any occurs in the night.

At Roncesvalles, in August, 1813, there fell upon a division of the British army a storm of hail, in which the stones ranged in size from a bean to a hen's egg. During a terrible storm that occurred at Cazorta, in Spain, on the 13th of June, 1829, the roofs of the houses were broken in by the hail. It is probable that such extraordinary masses as those which have been mentioned are formed by the union of several hailstones frozen together.

Mr. Darwin gives the following account of a hail-storm which occurred in the state of Buenos Ayres:

"We were here told a fact which I would not have credited if I had not partly ocular proof of it; namely, that during the previous night hail as large as small apples, and extremely hard, had fallen with such violence as to kill the greater number of the wild animals. One of the men had already found thirteen deer lying dead, and I saw their fresh hides; another of the party, a few minutes after my arrival, brought in seven more. Now I well know that one man without dogs could have killed only seven deer in a week. The men believed they had seen about fifteen dead ostriches, part of one of which we had for dinner: and they said that several were ranging about evidently blind in one eye. Numbers of smaller birds, as ducks, hawks, and partridges were killed. I saw one of the latter with a black mark on its back, as if it had been struck with a paving-stone. A fence of thistle-stalks round the hovel was nearly broken down, and my informer, putting his head out to see what was the matter, received a severe cut, and now wore a bandage. The storm was said to have been of limited extent; we certainly saw from our last night's bivouac a dense cloud and lightning in this direction. It is marvellous how such strong animals as the deer could thus have been killed; but I have no doubt, from the evidence I have given, that the story is not in the least exaggerated. Dr. Malcolmson also informs me that he witnessed in 1831, in India, a hail-storm which killed numbers of large birds, and much injured the cattle. These hailstones were flat, and one was ten inches in circumference, and another weighed two ounces. They ploughed up a gravel walk like musket balls, and passed through glass windows, making round holes, but not cracking them."

# CHAPTER XI.

## CLIMATE.

HUMBOLDT asserts that *climate*, taken in its most general sense, signifies all those states and changes of the atmosphere which sensibly affect our organs; temperature, humidity, variation of atmospheric pressure, a calm state of the air, or the effects of different winds, the amount of electric tension, the purity of the atmosphere, or its admixture with more or less deleterious exhalations, and, lastly, the degree of habitual transparency of the air and serenity of the sky, which has an important influence not only on the organic development of plants and the ripening of fruits, but also on the feelings and the whole mental disposition of man.

In order to understand what is meant by the term climate, let us suppose the earth to present a uniform flat surface, and to be composed of a stratum of rock perfectly alike throughout. Under these circumstances, all places in each hemisphere equidistant from the equator would receive the solar rays at the same angle, and, having the same capacity for absorbing and radiating heat, would possess the same temperature, and consequently the same climate. But matters are not thus arranged upon the earth's surface. There are causes which combine to modify the astronomical distribution of temperature, and to produce a more equal distribution of heat over the surface of the globe than would exist under the circumstances we have supposed; these are the influences of hills and dales, mountains and valleys, into which the surface of the earth is broken, the arms of the sea by which it is penetrated, and the network of running waters which are spread over its land masses. Hence it is that large regions are adapted to the abode and support of man, that would else, from extreme heat or cold, have been quite uninhabitable.

### I. *Causes which determine Physical Climate.*

The chief causes which determine physical climate are,—
1. The latitude of a country; that is, its geographical po-

sition with reference to the equator. 2. Elevation of the land above the sea-level. 3. The proximity to, or remoteness of a country from the sea. 4. The slope of a country, or the aspect it presents to the sun's course. 5. The position and direction of mountain chains. 6. The nature of the soil. 7. The degree of cultivation and improvement at which the country has arrived. 8. The prevalent winds. 9. The annual quantity of rain that falls in a country.

We shall now consider these influences separately.

1. *The latitude of a country*, and the consequent direction in which the solar rays fall upon its surface, are the principal causes of the temperature to which it is subject.

Within the tropics, the greatest heat is experienced, because the sun is always vertical to some portion of the globe within these limits, and the solar action is more intense when the rays are perpendicular to the surface; but as we recede from the equator they fall more obliquely, and because fewer of them are spread over a larger space, they are less powerful, and consequently less influential in promoting temperature. Bouger calculated that out of 10,000 rays falling upon the earth's atmosphere, 8,123 arrive at a given point if they come perpendicularly; 7,024, if the angle of direction is 50°; 2,831, if it is 7°; and only 5 if the direction is horizontal.

The latitude of a place is therefore of the first importance in determining its temperature, since a decrease of heat takes place with an increase of latitude as we travel along, at the same level above the sea, from the equator towards the poles. This is true of countries lying between the tropics and the poles, but it is not true of places situated between the tropics and the equator.

"If the ecliptic, as shown on a terrestrial globe, be examined, it will be seen that towards the northern and southern limits, for a considerable distance, it neither approaches nor recedes from the equator or the pole, but has a direction due east and west, This ecliptic is, in point of fact, the path of the point of *direct heat and sunlight* over the earth's surface. Thus, then, it appears that when this point has reached its nearest approach to either pole, it does not immediately turn back towards the other pole, but remains at that nearest distance for a considerable time; or, as it were, lingers there. It has been calculated that if the space between the tropics be imagined to be divided into three equal bands of the earth, the point of direct sun-light would be found to linger in each of the two outer bands three times and a half as long as in the middle band.

"This lingering of the point of direct heat and sunlight at its nearest approach to the poles is a necessary result of that simple and admirable provision by which the earth is made to revolve round the sun, rotating at the same time round an axis which has an inclined position, and which preserves its parallelism. The object of it is obviously to minister to the polar regions, in their due proportion, light and heat." *

* Professor Moseley's 'Astro-Theology.'

From this circumstance it is inferred that there is no decrement of temperature until we have passed the tropics; and this opinion is further strengthened by the fact that the snow-line in some places near the tropics is at a greater elevation than at the equator, an evidence of higher temperature.

2. *Elevation of the Land above the Sea-level.*—We may travel several miles from the equator towards the poles, along the level surface of the earth, before we become sensible of a diminished temperature; but immediately we begin to increase our elevation a rapid change of temperature is experienced, until we arrive at a point where constant frost prevails. This cold, which reigns in the higher region of the atmosphere, is due to the rarefaction of the air, and to the circumstance of that region being further removed from the heat which is reflected from the earth's surface. As we ascend the heat gradually diminishes, an ascent of only 1,000 yards causing the thermometer to fall 10°: this sinking, though not uniform with equal ascents, will go on until we reach the line of perpetual congelation. This beautiful provision, of course, increases considerably the number of habitable countries within the torrid zone.

By referring to the sketch at the bottom of Map 5, the Table on the opposite page will be understood. It is taken from Humboldt's work on Central Asia, and exhibits the heights of eternal snows in different latitudes.

The mountains of South America, immediately under the equator, present an epitome of the whole earth, in respect of temperature, and productions depending upon temperature. Here, in the deep and narrow valleys which are cleft down almost to the level of the sea, intolerable heat prevails; and as one climbs the lofty ridges, a single day's journey (though of course a laborious one upon so steep an escarpment) suffices to bring him from the temperature of the equator to that of the pole. There are some points in the steep ascents where one can stand and behold every characteristic form of vegetation, from the giant plants of the tropics to the lichens of the Arctic zone. Looking downwards into the valleys of the Andes, nothing appears but the richest and most exuberant tropical vegetation, palm-trees, and the banana, and the coffee-tree, and the sugar-cane, and the cow-tree (whose trunk being pierced yields a vegetable milk), the majestic forests, the juicy fruits, the gorgeous flowers of the tropics. Looking upwards, there are fields of European grain, and forests of oak and pine; further up, there are plants of the polar latitudes; and, last of all, a region where none grow but the *Arctic* lichens; beyond this the *Nevadas*, or snow-clad mountains, terminate the view.

### THE LIMIT of ETERNAL SNOWS.

#### NORTHERN HEMISPHERE.

| Place. | Latitude. | Limit of Perpetual Snow. |
|---|---|---|
| | N.<br>° ′ ° ′ | Feet. |
| Isle of Mageroe | 71 15 | 2,400 |
| Iceland, Oesterjokul | 65 00 | 3,100 |
| Siberia, Chain of Aldan | 60 55 | 4,500 |
| Kamtschatka, Volcano of Shevelutch | 56 40 | 5,200 |
| Altai | 49 15—51 00 | 7,000 |
| Alps | 45 45—46 00 | 8,800 |
| Pyrenees | 42 30—43 00 | 9,000 |
| Rocky Mountains | 43 03 | 12,500 |
| Sicily, Etna | 37 30 | 9,500 |
| Spain, Sierra-Nevada of Granada | 37 10 | 11,200 |
| Himalaya, N. side | 30 15—31 00 | 16,600 |
| ,, S. side | ,, | 13,000 |
| Mexico | 19 0—19 15 | 14,800 |
| Abyssinia | 13 10 | 14,100 |
| South America, Sierra-Nevada de Merida | 8 5 | 15,000 |
| ,, Volcano of Tolima | 4 46 | 15,300 |
| ,, Volcano of Purace | 2 18 | 15,400 |

#### SOUTHERN HEMISPHERE.

| Place. | Latitude. | Limit of Perpetual Snow. |
|---|---|---|
| EQUATOR. | S.<br>° ′ ° ′ | Feet. |
| Quito | 0 0 | 15,800 |
| Andes of Quito | 1 0—1 30 | 15,800 |
| Bolivian Andes { E. chain | 14 30—18 0 | 15,900 |
| W. chain | ,, | 18,500 |
| Chili, Volcano of Peuquenes | 33 0 | 14,700 |
| ,, Andes along the coast | 41 0—44 0 | 6,000 |
| Straits af Magellan | 53 0—54 0 | 3,700 |

3. *The proximity to, or remoteness of a country from, the sea*, is an important element in determining its climate. The sea being of a more uniform temperature than the land, the winds that sweep over it partake somewhat of the same character, and impress it upon the physical climate of the countries over which they range. A wind blowing from the ocean is loaded with vapours, but one passing over an extent of land is dry and parched. In our own islands, the south-

west and east wind are quite opposite in character: hence it is that islands and maritime districts enjoy a milder climate than inland regions in the same latitude; the colder winds from the sea temper the summer heat, and the warmer winds moderate the cold of winter.

London, though situated in a higher latitude, enjoys a milder winter and cooler summer than Paris. The temperate winters and summers of Ireland present a strong contrast to those of any other country under the same parallel. In proceeding from Western Europe in an easterly direction, a gradual increase of cold is experienced; for example, on comparing in the Tables the temperature of Dublin with that of Warsaw, in the same latitude, we find the mean annual temperature of the former to be 49·05, and of the latter 44·15, thus it is nearly 5° colder at Warsaw than at Dublin. Again, it is 6¼° colder at Moscow than at Copenhagen, though they are equidistant from the equator.

It follows, too, that countries in our hemisphere will be rendered hotter by having tracts of land to the south and sea to the north, and cooler when the relative position of these is reversed. This fact is exemplified by a comparison of the climate of India with that of Africa, north of the equator, the heat of the former country being much more supportable than that of the latter.

Throughout the whole continent of America there is a less degree of heat experienced as compared with corresponding latitudes in the eastern hemisphere. As an explanation of this, Humboldt advances the following statement:—"The comparative narrowness of this continent,—its elongation towards the icy poles,—the ocean, whose unbroken surface is swept by the trade-winds,—the currents of extremely cold water which flow from the Straits of Magellan to Peru,—the numerous chains of mountains abounding in the sources of rivers, and whose summits, covered with snow, rise far above the region of the clouds,—the great number of immense rivers that, after innumerable curves, always tend to the most distant shores,—deserts, but not of sand, and consequently less susceptible of being impregnated with heat,—impenetrable forests, that spread over the plains of the equator, abounding in rivers, and which, in those parts of the country that are the farthest distant from mountains and from the ocean, give rise to enormous masses of water, which are either attracted by them, or are formed during these acts of vegetation: all these causes produce, in the lower parts of America, a climate which, from its coolness and humidity, is singularly contrasted with that of Africa. To these causes alone must we ascribe that abundant vegetation, so vigorous and so rich in juices, and that thick and umbrageous foliage, which constitute the characteristic features of the new continent."*

4. *The slope of a country, or the aspect it presents to the sun's course*, has an important influence upon its climate. The angle at which the sun's rays strike the ground, and consequently the power of those rays in heating it, varies with the exposure of the soil relatively to that luminary. When the sun is elevated on the meridian 45° above the horizon, his rays fall perpendicularly on the side of a hill facing the south at an equal angle, while the plain below receives them at an angle of 45°. Supposing the north side of the hill to have a similar

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* 'Tableaux de la Nature.'

slope, the rays would run parallel to its surface, and their effect be very trifling; but if the declivity were still greater, the whole surface would be in the shade: this, though an extreme case, serves to show why temperature varies with the inclination of the earth's surface. Since the warmest part of the day is not when the sun is on the meridian, but, owing to the accumulation of the heat, two or three hours afterwards, it follows that, in our hemisphere, a south-south-west or south-western aspect is the warmest; and a north-north-east, or north-eastern, the coldest, if no local circumstances exist to make it otherwise.

Every possible variety, so far as the greater or less obliquity of the sun's rays is concerned, is introduced by the earth's surface being ploughed into deep fissures, in some parts sunk through large tracts into hollows, as in the countries surrounding the Caspian, in others elevated into table-lands, whose sides slope gradually north and south towards the rising and setting sun.

The effect of aspect is, of course, most strikingly seen in regions covered with high mountains. "Thus, under a vertical sun, the sides of the Andes receive the sun's rays as obliquely as they fall in our latitudes upon the earth's level surface; nay, as obliquely perhaps, as they fall in summer upon the level surface of the snows of Spitzbergen; whilst the Alps encounter on parts of their southern slopes as direct a heat as that which burns up the desert of Sahara; and on their northern they are as much hidden from the sun's influence as are the level snows of Lapland. In the Alps of the Valais, on the one side you may see the vine in luxuriant growth when the other is thick-ribbed with ice. Thus, too, the terraces and sloping plains which descend from the vast table-land of central Asia, where, inclining from its northern limit, they pass into the Steppes of Siberia, present, under the latitude of Edinburgh, a cold intense enough to freeze mercury; whilst upon the southern terraces of the opposite Himalaya slope, flourish, at different elevations, the pine-apple, the mango, the gigantic cotton-tree, and the saul. This tropical vegetation ascends then to an altitude of 4,000 or 5,000 feet, mingling itself, and by degrees giving way to the plants of a temperate region,—elms, willows, roses, and violets, destined in their turn, at a yet higher region, to yield to Alpine forms of vegetable life."*

5. *The position and direction of mountain chains.*—Mountains affect climate in more ways than one: they attract the vapours in the atmosphere, and causing them to condense, give rise to those violent rains which are often experienced in the neighbourhood of lofty ranges.

Scandinavia affords a striking example of this: at Bergen there fall annually 88½ inches of water, which is more than at any other city in Europe, and more than at many points situated within the tropics; this is because the clouds are driven forward by the s.w. winds into the fiords of Norway, where they are arrested by the mountains and accumulated, and the water (as it were) mechanically squeezed out of them.

Mountains also afford shelter from the winds. One reason why the central and southern parts of European Russia are exposed to greater cold than their latitude and inclination southward would lead us to expect, is the absence of any chain of mountains to protect them from the full influence of the winds blowing from the White Sea and Ural Mountains. The inhospitable climate of Siberia arises from its descent toward the north, exposing it to the winds of the Frozen Ocean; while, at the same time, the vast mountain chains that cross Central Asia intercept the southern winds, whose access would tend to mitigate the rigour of the atmosphere.

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* Professor Moseley's 'Astro-Theology.'

6. *The nature of the soil* is another cause which must very materially operate upon the climate. One soil acquires heat, keeps its acquired heat much longer, or radiates it more readily, than another. A soil which, from its porous character, allows the rain descending upon it to pass freely into the earth, will emit much fewer exhalations than one which retains the waters near the surface. All the varieties of soil,—light and open, vegetable moulds, gravelly and rocky tracts, stiff wet clays, and sandy plains,—have, it cannot be questioned, their different powers of radiation and absorption; and whether a district be clay or sand, bare or covered with vegetation, for a like cause greatly affects its temperature. It appears, from experiment, that the slightest differences in the sensible qualities of the surfaces of bodies are sufficient to give them different properties in respect to the radiation and absorption of heat; differences, for instance, of polish, of roughness or smoothness,—of colour, whether they be white or black,—of material, whether they be metallic, or vitreous, or vegetable substances, moist or dry. It cannot, therefore, be doubted that the differences of surface so observable in various kinds of foliage,—their darker or lighter colours, their more or less glossy leaves, the filamentous, downy substance, which sometimes covers them,—are all circumstances which affect the radiation of their heat with an infinite variation.

Thus clayey or marshy grounds lower the temperature, and, especially in hot and humid climates, affect the atmosphere in a manner pernicious to health. On the other hand, those which are light, stony, or calcareous, tend to make the atmosphere salubrious. The great cold, and the unwholesome air, that prevail in the Russian governments of Astrakhan and Orenburg, lying to the north of the Caspian Sea, are attributed partly to the saline nature of the soil; and it is well known that the arid tracts of sand in Africa and Arabia conduce not a little to the excess of heat under which those countries labour.

7. *The degree of cultivation and improvement at which the country has arrived.*—Without cultivation, few climates would be healthy or agreeable. In countries to which the labours of civilised man have never been extended, the rivers, spreading themselves over the low grounds, form pestilential marshes; and forests, thickets, and weeds, are so numerous and impenetrable, as to prevent the earth from receiving the beneficial influence of the sun's rays. The air, from these causes, is constantly filled with noxious exhalations. But the efforts of the human race, conducted with skill and perseverance, produce a surprising change: marshes are drained; rivers embanked; the soil, broken up by the plough, is exposed to the sun and wind, and the clearing away of the forests raises the temperature, and allows a freer circulation to the atmosphere. There is little doubt that many parts of Europe enjoy a milder climate now than they did in the time of the Romans, or even at periods much more recent. Several districts in North America have experienced, as the country has become more

widely settled, a similar improvement of climate. The destruction of forests may, however, be carried to a pernicious extent, either by depriving a country of shelter from particular winds, or (especially in hot climates) by lessening too much the quantity of moisture; it being well known that there is a great evaporation from the leaves of vegetables. The sultry atmosphere and dreadful droughts of the Cape de Verde Islands are owing to the destruction of the forests; and Greece, Italy, and other countries, are said to have been deteriorated in climate from the same cause. It is attributed to this also that the southern part of Iceland is more accessible than formerly to the cold which proceeds from the Arctic Ocean.

8. *The prevalent winds.*—The combined influence of the several causes of physical climate which we have been considering will be variously modified by the prevalent winds of a country. This is obvious enough, from what has been said in the Chapter on Winds, from which we learn that the character of a wind depends upon the region whence it comes, and the surface over which it passes. Great Britain, for example, would in a great measure lose its insular climate if its prevailing winds came across the Continent, instead of from the Atlantic Ocean.*

9. *The annual quantity of rain that falls in a country* constitutes an important feature of its climate. In general, more rain falls in islands and on sea-coasts than in inland districts, among mountains than in level regions, and within the tropics than in the other zones; the great heat which prevails in the equatorial regions causes the amount of evaporation to be much greater than in higher latitudes, and hence the atmosphere becomes charged with a greater quantity of moisture.

The mean annual quantity of rain which has been ascertained to fall at several places in various parts of the world is stated in the following Table, from which it will be seen that the quantity becomes in general less with the increase of the latitude, though with some exceptions, which are owing to local circumstances.

| Place. | Latitude North. | | Inches of Rain. |
|---|---|---|---|
| | ° | ′ | |
| Grenada | 12 | 0 | 126 |
| Kingston (Jamaica) | 18 | 0 | 83 |
| Calcutta | 22 | 39 | 81 |
| Rome | 41 | 53 | 39 |
| Paris | 48 | 49 | 21 |
| Plymouth | 50 | 23 | 37 |
| London | 51 | 30 | 24 |
| Liverpool | 53 | 25 | 34 |
| Kendal | 54 | 20 | 56 |
| Glasgow | 55 | 51 | 21 |
| Edinburgh | 55 | 57 | 24 |
| Upsal | 59 | 52 | 16 |
| Petersburgh | 60 | 0 | 16 |

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* *Physical Geography*, in the Library of Useful Knowledge.

The comparative moisture or dryness of the climate of any place cannot, however, be inferred from the annual quantity of rain; for the number of rainy days in the year is generally least in countries where the total quantity which falls is the greatest. Thus, in the Torrid Zone, the number of days in the year upon which rain occurs is much fewer than in the temperate regions of the globe; and in the parts of Europe lying to the south of the Alps, the number of rainy days is less than in the countries to the north of that mountain system, though the total quantity wich falls is generally greater. But, in tropical countries, the rain may be literally said to descend in torrents, with a degree of violence of which the experience of our latitudes conveys no adequate idea, and which is so great as frequently to render whole districts impassable within a few hours. At Bombay, as much as sixteen inches of rain are said to have been collected within twenty-four hours; and at Demerara, six inches are stated to have fallen within twelve hours. In the Torrid Zone, the rains generally follow the course of the sun; the rainy season in the northern half of the regions within the tropics usually occurring when the sun is to the north of the equator, and the dry season when the sun is to the south of that line, and similarly in the southern half of the same zone. There are, however, local exceptions to this; and, in some countries within or near the tropics, two wet and two dry seasons occur within the year.

The succession and alternation of heat and cold, rain and sunshine, wind and calm, and other atmospheric changes which we have been considering, and which take place in all parts of the globe, have, in several places been indicated and registered by the *thermometer*, *barometer*, *hygrometer*, *ombrometer*, *anemometer*, and similar instruments. From these observations, collected and recorded, the surface of the earth has been divided by boundary lines into various strips, according to these physical differences. Thus, the zones which embrace all the places having the same or nearly the same mean annual temperature have been called *Isothermal Zones*, and the lines marking out their limits have been termed *Isothermal Lines*; these we shall now proceed to describe.

### II. *Isothermal Lines.*

Isothermals (from ἴσος, *equal*, and θερμὸς, *heat*,) are lines drawn upon a map, connecting all places on the surface of the globe having the same mean annual temperature. If a traveller were to set out, say eastward, and visit in succession all those places which have the same mean temperature, he would trace out on the earth's surface what is called an *Isothermal Line*. As may be seen on Map 4, these *isotherms* form concave and convex lines, which diverge more and more from the parallels of latitude as they recede from the equator. Now the causes which influence the forms of these lines have been explained in the preceding chapter; but the principal of these is, elevation above the sea level.

Humboldt was the first to trace on a chart the isothermal lines, from observations made at about 360 different places. Since the publication of his chart in 1817, observations of this nature have been steadily multiplying: in the isothermal maps constructed by Professor Dove, of Berlin, the *isotherms* have been laid down from observations made at no less than 913 stations on the surface of the globe. The annexed Temperature Tables have been compiled from those communicated by this distinguished meteorologist to the British Association for the Advancement of Science, and published in their Reports for 1847—48.

From these Tables we might point off on a map all those places having the same mean summer temperature, and also those of equal mean winter temperature, and draw lines passing through these points. The lines connecting the points of mean summer temperature are called *Isotherals* (from ἴσος, *equal*, and θέρος, *summer*). The lines joining the points of mean winter temperature are termed *Isochimenals* (from ἴσος, *equal*, and χειμὼν, *winter*).

In the same way we might conceive lines drawn according to conditions depending on clouds, rain, wind, and like circumstances, if we had observations enough to enable us to lay down such lines.

We may easily comprehend that these climatic conditions have the greatest influence over the geographical distribution of organised beings. Many animals, especially quadrupeds, which cannot make such great migrations as birds, avoid extreme climates. If, therefore, a curve is passed through the points which limit on the north the area inhabited by these animals, this curve will almost coincide with an isochimenal. This is shown in the chart published by the celebrated geographer, Carl Ritter, on the distribution of wild and domestic mammifera in Europe. Thus, in Sweden, the elk still lives under 65° of latitude; but, in the interior of Siberia, it does not pass the 55th degree.

The same observations apply to the distribution of vegetables on the earth; but we must carefully distinguish arborescent vegetables from those which are merely annuals, and die each year after having produced seed. Trees cannot so effectually resist the rigours of winter as perennial herbaceous vegetables; however, if their period of flowering and fructification is not long, they rise even to high latitudes along the coasts of the Atlantic, while they remain much nearer to the south in the interior of the Continent.

| Countries. | Lat. N. | Long. W. | Elevation above level of Sea. | Winter. | Spring. | Summer. | Autumn. | Year. |
|---|---|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | Feet. | ° | ° | ° | ° | ° |
| Melville Island . | 74 47 | 110 48 | . . | —28·45 | —3·19 | 37·08 | —0·48 | 1·24 |
| Port Bowen . . | 73 14 | 88 56 | . . | —25·09 | —5·77 | 34·40 | 10·58 | 3·53 |
| Boothia Felix . | 69 59 | 92 1 | . . | —21·71 | —5·21 | 38·04 | 9·69 | 3·70 |
| Winter Island . | 66 11 | 83 11 | . . | —20·47 | 6·35 | 31·80 | 17·58 | 8·82 |
| Fort Simpson . | 62 11 | 121 32 | 250 | —11·04 | 26·10 | 59·16 | 26·24 | 25·12 |
| Iakutsk . . . | 62 1 | —129 44 | . . | —36·37 | 15·61 | 61·72 | 12·76 | 13·43 |
| Fort Franklin . | 65 12 | 123 13 | 230 | —16·66 | 14·05 | 50·23 | 21·12 | 17·18 |
| Nain . . . . | 57 10 | 61 50 | . . | 3·66 | 24·57 | 47·90 | 35·16 | 27·82 |
| Torneo . . . | 66 24 | — 23 47 | . . | 6·41 | 27·83 | 57·89 | 32·10 | 31·06 |
| Irkutsk . . . | 52 17 | —104 17 | 1,355 | 0·90 | 35·29 | 61·50 | 32·77 | 32·62 |
| Kazan . . . | 55 48 | — 49 7 | 150 | 6·34 | 36·20 | 62·39 | 36·91 | 35·45 |
| Umea . . . . | 63 50 | — 20 16 | . . | 13·47 | 33·16 | 57·42 | 37·45 | 35·37 |
| Petersburgh . . | 59 56 | — 30 18 | . . | 18·66 | 37·06 | 61·68 | 41·02 | 39·61 |
| Moscow . . . | 55 45 | — 37 38 | 400 | 15·20 | 40·96 | 63·97 | 39·94 | 40·02 |
| Quebec . . . | 46 48 | 71 17 | . . | 14·15 | 39·05 | 68·08 | 46·10 | 41·85 |
| Christiana . . | 59 55 | — 10 45 | 74 | 23·18 | 40·08 | 59·88 | 42·62 | 41·45 |
| Stockholm . . | 59 21 | — 18 4 | 128 | 26·04 | 38·21 | 60·43 | 44·41 | 42·27 |
| Halifax . . . | 44 39 | 63 38 | . . | 21·00 | 31·67 | 61·00 | 46·67 | 40·06 |
| Montreal . . . | 45 31 | 73 35 | . . | 17·79 | 45·76 | 71·40 | 48·08 | 45·76 |
| Toronto . . . | 43 40 | 79 22 | 340 | 25·43 | 42·34 | 64·63 | 46·81 | 44·81 |
| Warsaw . . . | 52 13 | — 21 1 | 351 | 24·91 | 43·05 | 63·21 | 45·41 | 44·15 |
| Delaware . . | 42 16 | 74 58 | 1,384 | 26·64 | 43·48 | 67·38 | 48·03 | 46·38 |
| Leipzig . . . | 51 20 | — 12 22 | . . | 31·79 | 45·72 | 60·25 | 47·86 | 46·41 |
| Copenhagen . . | 55 41 | — 12 35 | . . | 31·31 | 43·54 | 62·70 | 48·70 | 46·56 |
| Breslau . . . | 51 07 | — 17 02 | 373 | 29·19 | 45·73 | 63·61 | 48·42 | 46·74 |
| Dantzig . . . | 54 20 | — 18 41 | . . | 30·01 | 43·57 | 61·92 | 47·06 | 45·64 |
| Northumberland | . . | . . | . . | 37·08 | 44·64 | 57·87 | 47·64 | 46·68 |
| Edinburgh . . | 55 58 | 3 11 | 220 | 38·45 | 45·02 | 57·17 | 47·89 | 47·13 |
| Meiningen . . | 50 40 | — 10 30 | . . | 32·61 | 46·58 | 63·46 | 48·90 | 47·89 |
| Bremen . . . | 53 05 | — 8 49 | . . | 33·10 | 47·11 | 63·30 | 48·99 | 48·13 |
| Berlin . . . . | 52 30 | — 13 24 | 100 | 31·45 | 47·41 | 64·56 | 49·23 | 48·16 |
| Boston . . . | 42 21 | 71 4 | . . | 28·29 | 46·09 | 69·04 | 50·46 | 48·47 |
| Dublin . . . | 53 21 | 6 11 | . . | 39·83 | 47·16 | 59·57 | 49·63 | 49·05 |
| Plymouth . . | 50 22 | 4 7 | . . | 44·88 | 49·68 | 60·87 | 52·91 | 52·06 |
| Geneva . . . | 46 12 | — 6 10 | 1,258 | 34·04 | 52·21 | 70·36 | 54·25 | 52·71 |
| Vienna . . . | 48 13 | — 16 23 | 450 | 31·95 | 51·60 | 69·40 | 51·16 | 51·03 |
| Brussels . . . | 50 51 | — 4 22 | 262 | 38·01 | 49·04 | 64·04 | 51·60 | 50·68 |
| London . . . | 51 30 | 0 05 | . . | 39·50 | 49·06 | 62·93 | 51·83 | 50·83 |
| Neufchatel . . | 46 59 | 6 55 | 1,350 | 35·68 | 50·08 | 66·50 | 52·07 | 51·06 |
| Paris . . . . | 48 50 | — 2 20 | 114 | 37·85 | 50·62 | 64·58 | 52·20 | 51·31 |
| Bristol . . . | 51 27 | 2 36 | . . | 40·33 | 50·33 | 64·33 | 51·67 | 51·67 |
| Auckland . . | —36 51 | —174 45 | . . | 66·92 | 59·83 | 50·75 | 56·83 | 58·58 |
| Hobart Town . | —42 53 | —147 28 | . . | 63·06 | 51·55 | 42·14 | 52·75 | 52·37 |
| Turin . . . . | 45 11 | — 7 41 | 857 | 33·46 | 53·73 | 71·51 | 53·80 | 53·13 |
| Philadelphia . . | 39 57 | 75 01 | . . | 30·07 | 49·80 | 71·36 | 51·87 | 50·78 |
| New York . . | 40 43 | 74 1 | . . | 30·12 | 52·06 | 70·93 | 53·20 | 51·58 |

| Countries. | Lat. N. | Long. W. | Elevation above level of Sea. | Winter. | Spring. | Summer. | Autumn. | Year. |
|---|---|---|---|---|---|---|---|---|
| | ° ′ | ° ′ | Feet. | ° | ° | ° | ° | ° |
| Pekin . . . | 39 54 | —116 26 | . . | 28·23 | 55·51 | 75·17 | 54·22 | 53·28 |
| Washington . . | 38 57 | 76 55 | 115 | 37·76 | 56·19 | 76·74 | 56·87 | 56·89 |
| Nantes . . . | 47 13 | 1 33 | . . | 40·63 | 54·65 | 68·68 | 55·63 | 54·90 |
| Trieste . . . | 45 38 | — 13 46 | . . | 39·44 | 53·69 | 71·39 | 56·69 | 55·30 |
| Bordeaux . . | 44 50 | 0 35 | . . | 43·10 | 56·08 | 71·08 | 57·88 | 57·03 |
| Madrid . . . | 40 25 | 3 42 | 1,939 | 43·16 | 55·64 | 76·40 | 57·44 | 58·16 |
| Marseilles . . | 43 18 | — 5 22 | 140 | 45·22 | 55·91 | 72·93 | 59·21 | 58·32 |
| Rome . . . | 41 54 | — 12 25 | 160 | 46·73 | 58·25 | 74·24 | 62·75 | 60·49 |
| Monte Video . | —34 54 | 56 13 | . . | 77·33 | 68·00 | 57·33 | 64·77 | 68·83 |
| Quito . . . . | — 0 14 | 78 45 | 8,970 | 77·60 | 60·17 | 59·71 | 60·61 | 73·31 |
| Naples . . . | 40 52 | — 14 15 | . . | 47·65 | 57·56 | 74·38 | 61·46 | 60·26 |
| Genoa . . . | 44 24 | — 8 54 | . . | 47·33 | 58·81 | 75·08 | 62·97 | 61·05 |
| Lisbon . . . | 38 42 | 9 9 | . . | 52·52 | 59·66 | 70·94 | 62·48 | 61·40 |
| St. Helena . . | —15 55 | 5 43 | 1,764 | 63·87 | 64·96 | 58·41 | 58·38 | 61·40 |
| Mexico . . . | 19 25 | 99 6 | 6,990 | 53·64 | 63·42 | 65·23 | 60·13 | 60·60 |
| Norfolk (Virginia, U. S.). | 36 58 | 76 16 | . . | 46·95 | 62·91 | 78·30 | 66·69 | 63·71 |
| Messina . . . | 38 11 | — 15 34 | . . | 54·97 | 61·48 | 77·14 | 69·21 | 65·70 |
| Cape of Good Hope . . | —34 11 | 18 26 | . . | 66·95 | 62·00 | 54·39 | 59·73 | 60·77 |
| Alexandria . . | 31 13 | — 29 48 | . . | 64·43 | 69·31 | 76·89 | 69·04 | 63·03 |
| Barcelona . . | 41 23 | — 2 12 | 204 | 50·18 | 60·37 | 77·0 | 64·51 | 63·03 |
| Funchal . . . | 32 38 | 16 56 | 80 | 63·50 | 64·46 | 71·60 | 70·88 | 67·61 |
| Constantinople . | 41 0 | — 29 0 | . . | 40·94 | 53·00 | 71·36 | 60·56 | 56·47 |
| Cadiz . . . . | 36 32 | 6 18 | . . | 52·90 | 59·53 | 70·43 | 65·35 | 62·06 |
| Jerusalem . . | 31 47 | — 35 14 | 2,500 | 49·61 | 60·50 | 73·88 | 66·53 | 62·63 |
| Ionian Islands . | 38 0 | — 21 0 | . . | 58·06 | 60·37 | 76·89 | 69·04 | 63·03 |
| Malta . . . . | 35 54 | — 14 34 | . . | 58·06 | 60·37 | 77·0 | 69·04 | 63·03 |
| New Orleans . . | 29 58 | 90 7 | . . | 55·80 | 72·08 | 82·04 | 69·28 | 69·80 |
| Bermuda . . . | 32 20 | 64 50 | . . | 58·76 | 63·74 | 75·20 | 71·90 | 67·40 |
| Gibraltar . . . | 36 07 | 5 21 | . . | 57·93 | 66·25 | 77·82 | 67·76 | 67·44 |
| Tunis . . . . | 36 48 | — 10 11 | . . | 55·76 | 64·94 | 83·00 | 71·36 | 68·77 |
| Canton . . . | 23 8 | —113 16 | . . | 54·88 | 69·83 | 82·00 | 72·83 | 69·88 |
| Cairo . . . . | 30 2 | — 31 15 | . . | 58·52 | 73·58 | 85·10 | 71·48 | 72·17 |
| Bagdad . . . | 33 21 | — 44 22 | . . | 49·62 | 75·04 | 93·13 | 77·16 | 73·74 |
| Rio Janeiro . . | —22 54 | 43 16 | . . | 79·15 | 74·70 | 68·60 | 72·56 | 73·75 |
| Mocha . . . | 13 20 | — 50 54 | . . | 79·78 | 89·07 | 52·93 | 89·51 | 76·91 |
| Havannah . . | 23 9 | 82 23 | . . | 72·98 | 76·22 | 81·35 | 78·12 | 77·17 |
| Vera Cruz . . | 19 12 | 96 9 | . . | 70·88 | 77·00 | 81·92 | 78·26 | 77·02 |
| Seringapatam . | 12 45 | — 76 51 | 2,412 | 71·33 | 82·07 | 74·97 | 74·67 | 75·76 |
| Benares . . . | 25 18 | — 82 56 | 300 | 66·17 | 87·78 | 87·24 | 79·87 | 80·26 |
| Ava . . . . | 21 50 | — 96 5 | . . | 68·82 | 81·92 | 83·59 | 79·16 | 78·39 |
| Calcutta . . . | 22 35 | — 88 20 | 80 | 72·25 | 87·60 | 86·72 | 83·06 | 82·41 |
| Bombay . . . | 18 56 | — 72 54 | . . | 77·44 | 83·25 | 82·84 | 81·54 | 81·27 |
| Singapore . . | 1 17 | —103 50 | . . | 79·24 | 81·05 | 81·61 | 80·82 | 80·68 |
| Batavia . . . | — 6 9 | —106 53 | . . | 78·67 | 79·50 | 78·17 | 77·00 | 78·33 |
| Trincomalee . . | 8 34 | — 81 22 | . . | 77·33 | 79·93 | 83·90 | 81·85 | 80·75 |
| Madras . . . | 13 4 | — 80 19 | . . | 77·06 | 83·09 | 86·18 | 81·45 | 81·94 |

In the Temperature Tables, a *minus* sign placed before a degree of latitude indicates that the latitude is *south*, and placed before a degree of longitude denotes that it is east longitude.

# CHAPTER XII.

## ELECTRICAL AND MAGNETICAL PHENOMENA.

### *Electricity.*

ELECTRICITY (Greek ηλεκτρον, Latin *electrum*), signifying amber. The name given to the cause of a series of phenomena exhibited by various substances, and also to the phenomena themselves. We are ignorant of the nature of this cause; whether it be a material agent or merely a property of matter. But as some hypothesis is necessary for explaining the phenomena observed, it has been assumed to be a highly subtile imponderable fluid, identical with lightning, which pervades the pores of all bodies, and is capable of motion from one body to another. The first knowledge of electricity was due to the following out the observation made by Thales (B.C. 600), that amber, when rubbed, acquired the property of attracting light substances. It was subsequently observed that glass and various other substances, when rubbed, acquired the same property. Thus if a tube of glass, a roll of sulphur, a piece of sealing wax, or any resinous body, be rubbed with woollen cloth or silk, it immediately attracts light bodies, at a greater or less distance according to the strength of the electric fluid. The cause of this attraction is owing to *electricity*, excited by the friction, and the attraction itself is termed *electrical attraction*. It must be observed, however, that while some of the light substances adhere to the body which has been rubbed, or the *excited body*, as it is termed, others are repelled immediately after contact. After awhile the excited body loses its influence, but it may again be renewed by friction; and if the body be sufficiently excited, and touched by the knuckle or a metallic ball, there is a slight crack, and a spark (called the *electrical spark*) passes into the body presented to it. Bodies which, when rubbed or excited, exhibit the attractions and repulsions above mentioned, are called *electrics*, they are as follow, shell lac, brimstone, amber, jet. Resinous bodies of every kind, including pitch and wax. Gums of every kind, including camphor and caoutchouc. Glass and all vitreous and vitrified substances. The diamond, agate, and most other precious stones. Tourmaline, and other crystalline transparent argillaceous and silicious gems and stones. Bituminous substances. Silk of every kind and form. Dried animal furs and skins, hair, wool, feathers, paper, porcelain. Turpentine and various oils and fatty fluids. All dry gases. Atmospheric air. Steam of high elasticity. Ice at 0° Fahrenheit.

Those bodies which cannot be excited by friction, are called *non-electrics*, they are as follow:—Every metallic substance known. Well-burned charcoal. Plumbago. Concentrated and diluted acids and saline fluids. Water and moist vegetable matter. Living animal matter. Flame, smoke, steam. The former class are called *non-conductors*, because although they are capable of producing electricity, they do not allow it to pass easily through their substance; while the latter class are called *conductors*, because they readily transmit the electricity which they receive to any distance; and such is the rapidity of the electric fluid in motion that no perceptible length of time is required for its passage to any known distance. Electricity may be produced in various ways, but the simplest and usual mode of producing it is by friction, and for this purpose electrical machines are employed. When a body acquires more than its natural quantity of electricity, it is said to be *positively electrified*, and when the natural quantity is diminished the body is said to be *negatively electrified*. The elasticity produced by glass, and that produced by resinous substances, are not identical; since each is found to attract what the other repels. Hence has arisen the theory of two distinct electricities; the one being called the *vitreous*, and the other the *resinous* electricity. The vitreous electricity is also sometimes called *positive*, and the resinous *negative* electricity, in consequence of theoretical views entertained on this subject. The fundamental laws of electricity are as follows:—Bodies in opposite states of electricity attract each other; bodies in similar states, that is both positively or both negatively electrified, repel each other; and bodies in a natural state attract both those that are positively, and those that are negatively electrified. Electricity, when accumulated in large quantities, becomes an agent capable of producing the most sudden, violent, and destructive effects, as in thunder storms; and even in its quiescent state it is extensively concerned in the operations of nature. It is an important chemical agent, and its use has been lately much extended in the arts and manufactures, but particularly in its application to the wires of the Electric Telegraph.

Electricity has been subdivided into the following different kinds according to the methods employed for producing it.

1. *Frictional Electricity*, or electricity produced by rubbing certain electrical bodies together.

2. *Voltaic or Galvanic Electricity*, which includes all those electrical phenomena arising from the chemical agency of certain metals with different fluids. The agent itself is denominated *galvanism*, after its discoverer Galvani, while the instruments used for exciting and accumulating it are called Voltaic, in honour of Volta, who first contrived this kind of apparatus.

3. *Magneto-Electricity*.—The name given to a peculiar kind of electrical excitation, caused by the influence of magnetism on metallic wires, exerted either by the natural magnet termed the loadstone, or by a combination of steel bars forming a compound artificial magnet.

4. *Thermo-Electricity*, which is developed by heat. When wires or bars of metal of different kinds are placed in close contact, end to end, and disposed so as to form a continuous circuit, and heat then applied to the ends or junctions of the bars, electric currents are produced.

5. *Animal-Electricity*.—This term has been applied to the electricity developed in the organs of certain fishes, such as the torpedo, which is usually taken in forty fathoms of water on the coast of France and England, and in the Mediterranean, and the gymnotus which is found in the fresh waters of South America. These fishes possess an electrical power derived from a peculiar organ acted on by a fluid, and which enables them at will to excite a peculiar and very strong electrical action.

6. *Atmospheric, or Natural Electricity*, is that which is developed in the atmosphere, and with which we are at present concerned.

### I. *Atmospheric Electricity*.

The atmosphere usually contains a quantity of electricity, and the instruments used for indicating and measuring the amount of electricity in it are called *electrometers*. If we take a glass jar and fit into it an upright pointed metallic rod, and attach loosely two fine straws to the lower end which enters the jar, the pointed end of the rod will collect the electricity which will be conducted to the straws; these becoming similarly electrified will recede from each other, the amount of divergence measuring the intensity of the fluid. Insulated rods of iron are erected for ascertaining the amount of electricity in the air at great elevations. At the Royal Observatory, Greenwich, the conductor is a conical tube of thin copper about 40 feet in height; to the top of the tube a lamp is affixed, its ascending stream of smoke and heated air being an excellent collector of electricity.

Experiments are made in the higher regions of the atmosphere by the aid of kites and balloons; the string of the kite should be wound round with fine wire, in order to convey the electric fluid from the sky; and it must also be insulated, by attaching the lower end either to a silken cord or a glass pillar. Metal rods are placed against houses and the masts of vessels to conduct the electricity from the atmosphere to the earth, and thereby prevent them from being struck with the fluid. In all apparatus for collecting atmospherical electricity the most careful and certain arrangements should be made for conveying harmlessly to the earth any excess that may accumulate. By the aid of the instruments just described much important knowledge has been acquired in regard to the electricity of the atmosphere.

*Electric condition of the Atmosphere.*—In the ordinary state of the atmosphere, its electricity is invariably positive; but when the sky is overcast, and the clouds are moving in different directions, it is subject to great and sudden variations, rapidly changing from positive to negative, and back again, in the space of a few minutes. Upon the first appearance of fogs, rain, hail, snow, and sleet, the electricity is generally negative; it then changes to positive, gradually increasing in strength, and then decreasing in the same manner; the alternations both in the strength and nature of the electricity occurring every three or four minutes. Similar changes are observed upon the approach of a thunder-cloud. The atmosphere is highly electrical, either when hot weather succeeds a series of wet days, or wet weather follows a series of dry days.

*Annual Variation in Intensity.*—The electricity of the atmosphere is stronger in winter than in summer, and, by comparing observations from month to month, a gradual decrease is perceived from January to July, but an increase from July to January. During the winter the amount of electricity increases with the cold.

*Daily Variation.*—At sunrise the electricity of the air is weak, but as the day advances, it increases in power, until six or seven o'clock, A.M. in summer, eight or nine in spring and autumn, and ten or twelve in winter; it then begins to diminish, and by two P.M. is hardly stronger than at sunrise, In summer, it continues to decrease till some time between four and six P.M, and in winter is weakest about five P.M. After this period the electricity again becomes stronger, advancing in intensity until about two hours after sunset, when it once more begins to abate, growing more and more feeble until sunrise. Thus, during the day, there is a regular fluctuation in the strength of the atmospheric electricity, two periods occurring when its intensity is greatest, and two when it is least.

*Variation in Altitude.*—The electricity of the air increases in strength with the altitude. This is shown by the following experiment, made by Bequerel and Breschet, at the monastery upon the Great St. Bernard. Having extended upon the ground a piece of gummed silk, 10 feet long and 7 feet wide, the experimenters placed upon it an electrometer, to this they attached one end of a silk cord, into which was twisted a fine wire, the other end of the cord being fastened to an iron arrow. By means of a bow, the arrow was shot upwards to the height of 250 feet; and as in its ascent the electricity of the air was gradually collected and conveyed along the wire to the electrometer, the straws of the latter were seen to diverge more and more, and at length to strike the sides of the glass jar. When the cord was detached, the electricity of the straws was discovered to be positive. In order to determine whether this increased divergence was really caused by the superior energy of the electricity residing in the higher regions of the atmosphere, the arrow was discharged horizontally to the same distance as before; but, as it speeded on its course, no increased electric action was manifested by the electrometer. Experiments for the same purpose were made by two celebrated French philosophers, Gay Lussac and Biot, during their aërial voyage in 1804. From the car of their balloon was suspended a wire 170 feet long, to the lower end of which a metallic ball was attached; the upper end being connected with an electrometer in the car. By means of this apparatus, these observers were enabled to note the electrical changes occurring in the atmosphere at different heights; and, from their various observations, arrived also at the conclusion, that the electricity of the atmosphere was positive, and increased in strength with the altitude.

*Origin.*—One of the most abundant sources of atmospherical electricity is evaporation. It was shown by Volta, whose experiments were confirmed by those of Saussure, that electricity was produced when water was evaporated. But it appears from the late researches of Pouillet, that this is only the case when water is not pure, and chemical decompositions occur. If distilled water is evaporated, no electricity is developed; but if a little chalk, lime, salt, or other foreign matter is dissolved in the water, the rising vapour is then positively electrified, and the vessel containing the fluid negatively. Now the waters of the earth are generally in this latter condition, being seldom pure, and the vapours, which are constantly ascending from the ground, will therefore possess positive electricity, and the earth negative. The briny waves of the ocean also contribute their share, and supply the air with a great amount of positive electricity. The process of evaporation advances invisibly and in silence; and, for this reason, we might easily undervalue its agency in accumulating those vast stores of electric matter which arm the storm with such terrific power. But when we reflect, that more than two hundred millions of hogsheads of water are computed to rise daily in vapour from the Mediterranean, we shall find no difficulty in believing, that this influence is one of the most energetic causes of atmospherical electricity.

*Condensation*, or the change which vapour undergoes when returning to a fluid state by a decrease of temperature, is another fruitful source of electricity. This is shown from the great amount of electricity occasioned by the condensation of steam, as it issues from the boiler of an engine. In one instance, the steam which rushed from the safety-valve of an insulated locomotive, was found to develop seven times the amount of electricity produced by an electrical machine, having a plate of glass three feet in diameter, and making seventy revolutions in a minute. Machines in which the electricity was generated by steam, have been constructed of such power, that a spark of 22 inches long has been obtained from the prime conductor, of sufficient energy to inflame shavings.

*Vegetation.*—The vegetable kingdom also supplies the air with a great amount of electricity. Plants during the day exhale oxygen gas; in the night, carbonic acid gas; and from the experiments of Pouillet it appears that positive electricity rises with the latter when the seeds first sprout, leaving the earth in which they are placed negatively electrified. The same results probably occur during the life of the plant.

*Combustion* is still another source of electricity. When any substance is burning, positive electricity escapes from it, while the substance itself is negatively electrified; the atmosphere is therefore the reservoir of all the positive electricity originating in this manner.

*Friction.*—In accounting for the electricity of the atmosphere, the effect of friction is not to be disregarded. If a piece of silk is shaken in the air, it becomes electrified; and it is highly probable, that when masses of air, moving in contrary directions, encounter each other, electricity is developed by the friction of their surfaces. Such will be the effect, according to Kaemtz, when the masses differ in respect to moisture and temperature; the warmer then becomes positively electrified, and the colder negatively. The action of the wind upon terrestrial objects, as rocks, buildings, trees, and hills, may possibly in like manner produce electricity.

## II. *Magnetism.*

*Magnetism* is that branch of science which treats of the properties of the magnet, or, in other words, the power of the loadstone. The term is also applied to that peculiar property, occasionally possessed by certain bodies (more especially by iron and some of its compounds), whereby under certain circumstances they attract or repel one another according to determinate laws. *Animal Magnetism* is a sympathy supposed to exist between the magnet and the human body, by which it is said that the magnet is able to cure diseases.

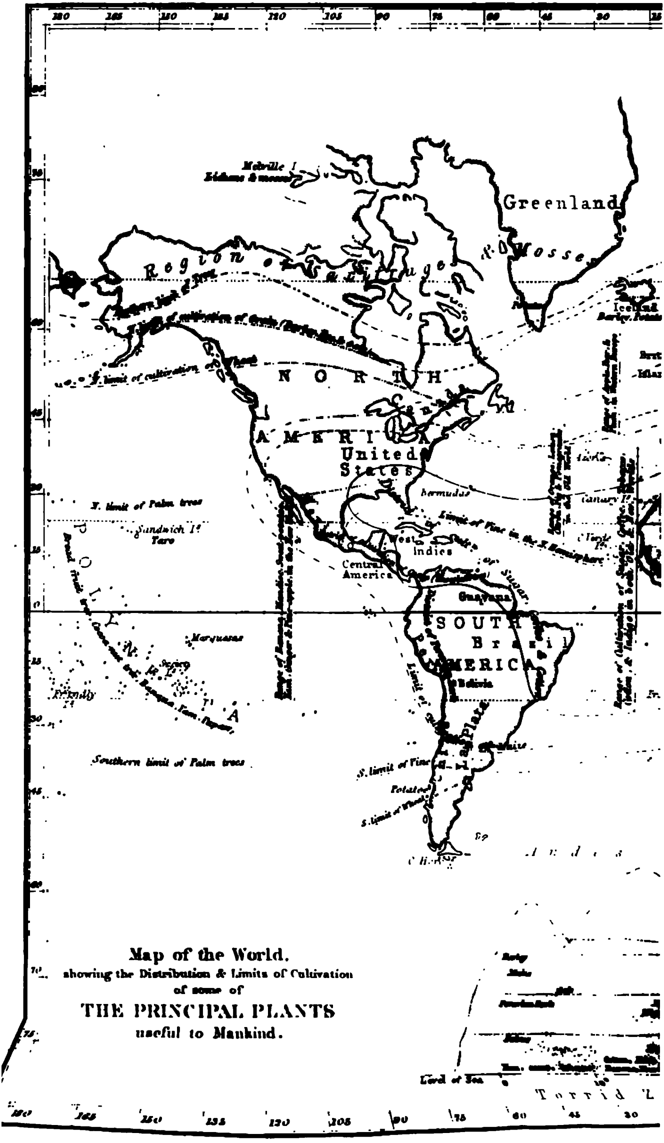
*Terrestrial Magnetism* is the name given to the magnetic power supposed to reside in the earth, which gives the needle its directive power, and causes it to dip, and which also communicates magnetism to iron and steel placed in certain situations. It is this kind of magnetism that we have at present to consider.

A body which exhibits magnetic properties is called a *magnet.* If a light and slender rod or bar of magnetised iron be suspended by or mounted upon its centre of gravity, so as to allow it to move freely in any direction, it is called a *magnetic needle.* If it be so mounted as to move only in a vertical direction, it is then called a *dipping needle.*

A magnetic needle so suspended as to turn only horizontally, assumes, when left to itself, a determinate direction with respect to the earth. Its poles place themselves nearly in a plane passing through the geographical poles of the earth; this direction consequently corresponds nearly with the meridian of the place of observation: when disturbed from this position, the needle returns to it after a series of oscillations.

If the needle be suspended so as to move freely in a vertical direction, it is found not to maintain a horizontal position; but one of its poles (in this hemisphere the north) inclines downwards towards the earth. At the magnetic poles of the earth (*see* Map IV.), the direction of the needle would be vertical; but the inclination diminishes as we recede from the poles towards the equator, and at the *magnetic equator*, which varies greatly from the geographical one, the needle becomes horizontal. A needle properly prepared for exhibiting this inclination, is called a *dipping needle.* A dipping needle, before being magnetised, should be as equally balanced as possible, so as to remain at rest in any direction in which it may be placed. The angle which the needle makes with the horizon at any place, is called the *dip* at that place. The tendency of the needle to dip is counteracted in the mariner's and surveyor's compasses, by making the south ends of the needles intended to be used in northern latitudes somewhat heavier than the north ends. A needle well balanced in this latitude remains sufficiently horizontal for use in any part of the northern temperate zone, except for delicate experiments. Compass-needles intended to be employed on voyages or travels, where great variations in latitude may be expected, are provided with a small sliding weight upon the magnetic needle. By a proper adjustment of this, the greater or less tendency to dip is counterbalanced. In passing from the northern to the southern hemisphere, the weight must be transferred from the south to the north pole of the needle.

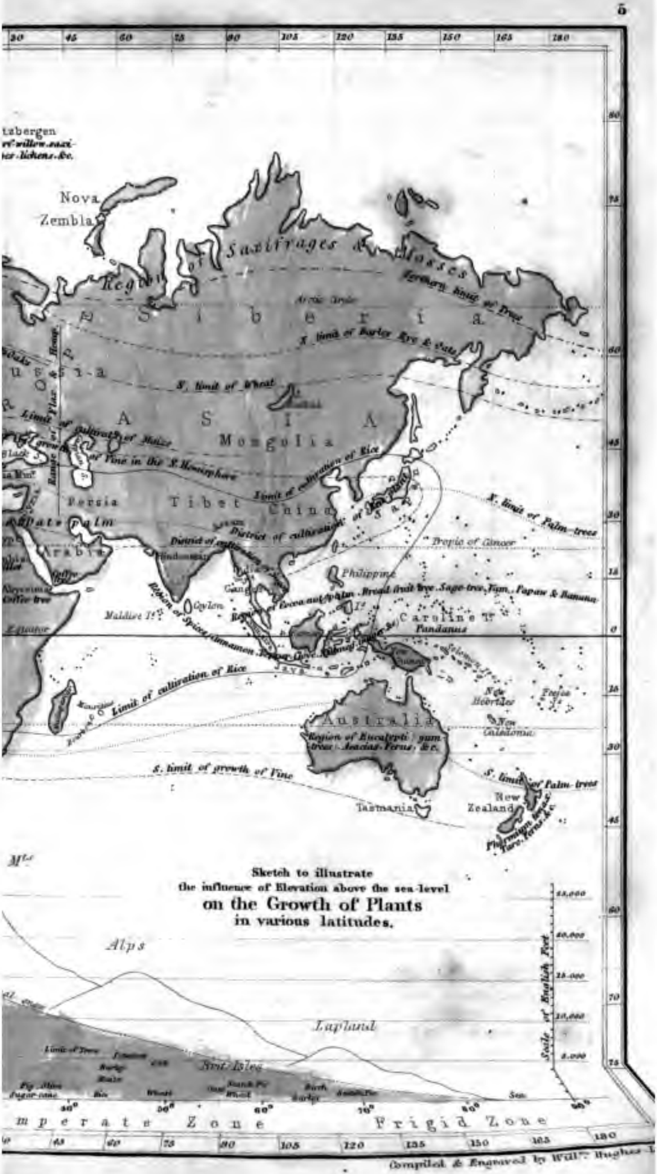
On comparing the directions assumed by the needle in its various positions with regard to the earth, with those assumed by a magnet in reference to another magnet, a great similarity is found to exist between them. This led to the opinion, which was for a long time entertained, that the earth was itself a magnet, or that it contained within it large magnetic bodies, under the influence of which the magnetic needle assumed these various directions, as a small needle does when placed in various positions near to a bar magnet. But there is another mode of accounting for the directive tendency of the magnet in respect to the earth; and that is, by supposing, instead of magnetised bodies within the earth, lying parallel to the direction of the needle, currents of electricity passing around the earth, within it, but near the surface, at right angles with that direction. This would identify the directive power of the needle in respect to the earth, with its directive tendency in regard to a current of electricity. And this is, in fact, the view at present adopted. The direction of the needle in respect to the earth is not fixed. Its *variation*, that is, its deviation from the true geographical meridian, is subject to several changes, more or less regular; and this deviation is different at different places upon the earth's surface: the angle included between the geographical meridian and the magnetic meridian is at present (1852) 23° 40′ at Greenwich. So also is the intensity of the action exerted on the needle by the earth, subject to changes as shown by the number of oscillations made by it in a given time. When examined by means of apparatus constructed with great delicacy, the needle is found to be seldom at rest. The earth has four magnetic poles, two strong and two weak; the strongest north pole is in America, the weakest in Asia. The line of no variation on the earth's surface differs considerably from the magnetic meridian; and the lines of equal variation and equal dip are not exactly meridians and parallels of latitude to the magnetic pole. The action of the magnetism of the earth at its surface is, therefore, irregular. The variation of the needle at any place is found by observing the magnetic bearing of any heavenly body whose true position at the time is known. It is immediately obtained by comparing the direction of the needle with the north star when it crosses the meridian. An observation of the sun, however, is usually preferred, from which we can calculate what is termed "the variation of the compass." The aurora borealis is found to affect a delicately-suspended magnetic needle, causing it to vibrate constantly, but irregularly during its continuance, and especially when the auroral beams rise to the zenith; if the aurora is near the horizon, the disturbance of the needle is very slight. When the beams unite to form a *corona*, its centre is generally in or near the magnetic meridian. Within a few years, a considerable number of magnetic observatories have been established in various parts of the world, for the purpose of making systematic and corresponding observations in relation to terrestrial magnetism. At these stations the variation of the needle, and the intensity of the earth's action upon it, are observed and recorded almost hourly, and stated days at intervals of a few minutes only. These observations, made by means of excellent instruments, and at the same time in widely remote regions, admit of comparison with each other, and can hardly fail to throw light on many parts of this important and intricate subject



Melville I.
Lichens & mosses
Greenland
Region of Lichens & Mosses
Iceland
Barley. Potato
Northern limit of Trees
N. limit of cultivation of Grain, Barley, Rye & oats
N. limit of cultivation of Wheat
NORTH AMERICA
Canada
United States
Bermudas
Canary I.
N. limit of Palm trees
Sandwich I.
Taro
Limit of Vine in the N. Hemisphere
West Indies
Central America
Guayana
Sugar
SOUTH AMERICA
Brazil
Bolivia
Plata
Marquesas
Friendly I.
Bread fruit tree, Cocoa nut tree, Banana, Yam, Papaw
Southern limit of Palm trees
S. limit of Vine
Potatoes
S. limit of Wheat
Cape Horn
Lord of Sea
Torrid Z.
POLYNESIA
Range of Bananas, Manioc, Sweet potato, Cacao, Ginger & Pine-apple in the New World
Range of cultivation of Sugar, Coffee, Indigo & Cotton in both Old & New World
180
165
150
135
120
105
90
75
60
45
30
15
0

**Map of the World.**
showing the Distribution & Limits of Cultivation
of some of
THE PRINCIPAL PLANTS
useful to Mankind.

L.



**Sketch to illustrate the influence of Elevation above the sea-level on the Growth of Plants in various latitudes.**

Compiled & Engraved by Will™ Hughes

# CHAPTER XIII.

## MAP V.

### GEOGRAPHICAL DISTRIBUTION OF PLANTS.

BOTANICAL GEOGRAPHY is a branch of natural science which opens up a wide field of interesting and profitable inquiry. There is scarcely a spot on the earth's surface which does not exhibit some characteristic form of vegetable life. Vegetation is seen either teeming with luxuriance beneath the glowing heat of a tropical sun, or clinging to existence under the extreme cold of the Arctic Zone. It puts forth its energies, and flourishes, on the hardest rock and in the softest soils; amidst the lofty regions of everlasting snow, and in springs at the temperature of boiling water; on the mountain top, and in deep caverns to whose dark recesses the sun never lent a cheering ray. The surface and beds of rivers and lakes present their peculiar vegetation; even the surface of marshes and pools is clothed with a vegetable slime. The "mighty waters," too, almost throughout their whole extent, exhibit an abundant vegetation, from the vast meadows of gulf-weed that float upon their surface, to the laminaria of the submarine forests which lie "in the deep bosom of the ocean buried."

The life and healthy vegetation of plants depend upon *light*, *heat*, and *moisture*.

It is light that gives to plants the beautiful green colour, the intensity of which increases with the brilliancy of the light. "Plants always turn towards the light; the guiding power we know not, but the evidence of some impulsive or attracting force is strong, and the purpose for which they are constituted to obey it is proved to be the dependence of vegetable existence upon luminous power."*

Heat is another essential, which determines the condition of plants by the amount of it which prevails during the season of vegetation; that is, how temperature is distributed over the periods of germination, growth, blossoming, and maturation of the fruit. Without moisture there can be no vegetation, and this element is supplied to the plant in three different forms; that of vapour which the plant absorbs,—that of liquid water by which some plants are surrounded,—and that of moisture, which the plant extracts in a peculiar state, as nutriment, from the earth. The development of plants is further dependent upon the chemical qualities of the soil in which they live, whether it be composed of pure or mixed earths, or of soil rich in clay or vegetable mould.

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* 'The Poetry of Science,' by Robert Hunt.

The sciences of botany, physiology, and agricultural chemistry, enable us to investigate the structure and nature of plants, and to examine in detail the treasures of the vegetable kingdom. The business of the physical geographer is only to mark its general arrangements: we shall notice these, and then pass on to those plants which form food for man.

From the most recent computations it would appear that botanists are at present acquainted with more than 120,000 distinct species of plants. These are divided into the following three great classes, which differ materially in their structure:—

1. *Cryptogamous*, or flowerless plants, embracing ferns, mosses, lichens, fungi, and sea-weeds.

2. *Endogenous plants*, which have their stems increasing from within, as sedges, rushes, and the numerous grasses, comprehending the most important of all vegetable tribes, viz., the valuable pasture and all the corn-yielding plants, wheat, barley, oats, maize, rice, the sugar-cane, &c., with lilies and the palm family. These are also called *monocotyledons*, from having only one seed-lobe.

3. *Exogenous plants*, which have their stems growing by additions from without: this is the most perfect, beautiful, and numerous class, embracing all the forest trees of the temperate and colder zones, as the oak, elm, pine, chestnut, poplar, hazel, willow, birch, &c., with some of the stateliest members of the tropical forest, as the mimosa, tamarind, and the trees yielding logwood, Brazil wood, &c., most of the flowering shrubs and herbs, as the rhododendron, azalea, arbutus, thyme, sage, lavender, mint, rosemary, with the plants yielding castor, croton, and many other oils; also the dahlia, artichoke, thistle, lettuce, marigold, dandelion, daisy, &c. These are also called *dycotyledons*, from the seed consisting of two lobes.

The last two classes belong to the *phœnoyamous*, or flower-bearing plants.

Plants, in one or other of their varied forms, are scattered over the whole extent of the globe, and their geographical distribution has, for a long period, engaged the attention of some of the most distinguished naturalists. As the *stations* and *habitations* of plants are the first elements of botanical geography, we shall, in the first place, define the meaning of these terms.

By *station* is meant the peculiar nature of the locality where each species is accustomed to grow, and it has reference to climate, soil, humidity, light, elevation above the sea, and other analogous circumstances. Thus, the station of a plant may be a salt-marsh, in a temperate climate, a hill-side, the bed of the sea, or a stagnant pool.

By *habitation* is meant the region or part of the globe in which each species is most common. The habitation of a plant may be Europe, North America, or New Holland, between the tropics, &c.

The temperature of the air seems to be the chief agent in limiting the range of any vegetable species; but it is not so much the mean annual temperature, or the extreme temperature as regards both heat and cold, that defines the boundaries of particular kinds of plants, as the distribution of temperature among the different months of the year, especially in reference to the heat and duration of the summer months. Isothermals cannot, therefore, rigorously determine a vegetable zone; but, as certain divisions are necessary for reference and comparison, we shall in the next section adopt the arrangement by which, according to these lines, the surface of the globe is divided into eight vegetation zones or belts.

## I. *Vegetation Zones.*

1. *The Equatorial Zone of Palms and Bananas* extends on both sides of the equator of temperature to about 15°. Its temperature ranges from the maximum heat to 70°. This may also be distinguished as the region of the spices and aromatic plants: it includes the Molucca group of islands and the northern part of South America. The region of medicinal barks is that of the elevated regions of South America, from 1,200 to 10,000 feet above the level of the sea.

2. *The Tropical Zone of Tree-Ferns and Figs*, from lat. 15° to the tropics, having a mean annual temperature of 76°. In the Old Continent the date-palm flourishes; in Western Africa is the peculiar genus *Adansonia*, the baobab, or monkey bread, the largest known tree in the world. In both the Indian peninsulas, monster fig-trees, and woods of aromatic barks, as the cinnamon and cassia, abound.

3. *The Sub-Tropical Zone of Myrtles and Laurels*, from the tropics

to lat. 34°, having a mean annual temperature of 76°. This region is distinguished in the New World by various species of conifers, oaks, and walnuts. In the southern part of North America, the magnolias, chiefly large trees, with large leaves and highly odorous flowers, and the palmetto-palm. On the Old Continent, the slender date-palm soars aloft, and the tender-leaved acacias flourish. Arborescent euphorbiæ, which with their leafless prismatic stems so singularly imitate the cactuses of America, give a remarkable feature to the flora of the Canary Islands. Within the above limits the palm family is numerous throughout the continent of Asia.

4. *The Warm Temperate Zone of Evergreen Trees*, from lat. 34° to 45°, mean annual temperature 58°.

The European portion of this region is that which has been most thoroughly investigated. It is characterized by the presence of evergreen woods, and by the general absence of the rich grassy meadows and verdant turf which form so striking a feature in the vegetation of more northern Europe. Among its most characteristic plants are the ilex, the cork-tree, and other evergreen oaks, the bay, the arbutus, the pomegranate, the myrtle, the olive, the pistachias, and the stone-pine and cypress. The warm temperate zone is the true native region of the vine. The fragrant cistuses, or rock-roses, acquire their maximum in the Spanish peninsula, where the *cistus ladaniferus* frequently extends over many square leagues to the exclusion of almost every other plant. The beautiful oleander clothes the margin of streams; narcissuses, hyacinths, and other showy bulbous plants abound; multitudes of aromatic labiatæ give a decided character to the Mediterranean flora; and the dwarf palm forms the connecting link by which the vegetation of Europe passes into that of the south. In the New World this region is marked by a great variety of oaks and firs.

5. *The Cold Temperate Zone of European Trees*, between 45° and 58°, mean annual temperature 48°. This region, which comprises the lake district in the New World, and is bounded in the Old Continent on the south by the Pyrenees, Alps, and Caucasus, is characterized by vast forests of different species of pine, and by deciduous trees, which take the place of the evergreens of the warm temperate zone. In central and western Europe there are extensive woods of chestnut, oak, and beech trees. In the more eastern portion, the lime and elm contribute abundantly to the composition of forests.

6. *The Sub-Arctic Zone of Conifers* from lat. 58° to the Polar circle, mean annual temperature 40°. This region consists of widely-extended masses of forest, including firs and pines, Siberian stone-pines, birch, aspen, and in Siberia the larch. By brooks and on damp soil the willow and alder occur; on dry hills grow the rein-deer lichen and Iceland moss. A rich carpet of variegated flowers serves for the decoration of this zone.

7. *The Arctic Zone of Rhododendrons*, from the Polar circle to lat. 72°, mean annual temperature 30°. This region is characterized by the *rhododendron laponicum*, by the abundance of mosses and lichens, and by the presence of the saxifrages, crow-foots, and gentians; the chickweed tribe, sedges, willow, and fir.

8. *The Polar Zone of Alpine Plants and Red-Snow Algæ*, beyond lat. 72°, the region of everlasting ice and snow, in which all animal life goes out.

To the south of the equatorial zone, the plants of Africa are little known, except about its southern extremity, which is covered over with brilliant heaths; proteas, diosmas, and restios abound, and the strange misshapen zamias confer a most singular physiognomy on the dry desert regions of this portion of the globe. Here also is the true home of the beautiful pelargoniums, and of the mesembryanthemums, and the strange-looking, carrion-smelling stapelias.

In South America there are immense forests of palms and mixed species of trees, with climbing and parasitic plants, which extend to the lower part of the basin of the Rio de la Plata and the plains to the west of Buenos Ayres. The Antarctic region, formed by the countries near the Straits of Magellan, has a vegetation somewhat similar to that of the north temperate zone. The Polar forms are found in the species of saxifrage, gentian, arbutus, and primrose.

The flora of the temperate parts of Australia, and that of Van Diemen's Land, is characterized by the presence of multitudes of eucalyptuses and other myrtaceous plants, and by acacias, which, instead of leaves, have flattened leaf-stalks, called phyllods. Banksias and epacrides abound; and among the anomalous forms of vegetation which give a peculiar physiognomy to the flora of this region may be mentioned the grass-trees and the casuarinas. The flora of New Zealand comprehends several which belong to the extremities of America, Africa, and Australia.

In the year 1807 appeared Humboldt's "Essay on the Geography of Plants," wherein he sought to bring the observed peculiarities in the distribution of vegetables into connexion with the specialities of climate; but ten years later he made his last grand step, and included the whole earth in one intelligent glance; he made the geography of plants part of the theory of the earth, and showed the dependence of the distribution of plants on a great scale, as on a small, upon the physical qualities of the globe.

## II. *Food Plants.*

Man, in almost every clime, has selected *summer plants* for food; that is, such plants as complete their whole vegetative processes within the course of a few months. These, for the most part, possess a subterraneous and usually tuberous roots, which sends up shoots above the soil; after some time, flowers appear, and afterwards fruit. During the remainder of the year, the plants sleep, as it were, beneath a protecting coverlet of earth, and are thus beyond the influence of excessive heat or cold. By the cultivation of these plants man has rendered himself independent of the destroying action of the dry season in semitropical regions, and of the killing influence of the winter cold in higher latitudes. Among the arborescent forms of the true food plants, the most important are the *bread-fruit*, the *cocoa-nut*, and the *date*, and these have become objects of culture, and furnish in certain regions the chief food of large bodies of men.

The ranges of the principal food plants are laid down on the map, and the sketch indicates their vertical distribution. The succession of different species of plants which is observed upon the sides of mountains was first noticed by the eminent botanist Tournefort, who made a journey to the Levant; and in the ascent of Mount Ararat it struck him that in its gradual elevation above the level of the sea the vegetation assumed essentially different characters, and that these changes corresponded very closely with what was observed in the progress from Asia Minor to Lapland. This change in the vegetable species is strikingly illustrated on the slopes of the Himalaya, the Alps and Pyrenees, Teneriffe, and the chain of the Andes.

The principal food plants are as follow :—

In the Old World the *grains* or *cereal grasses* (with the exception of *maize*, which more especially belongs to America), namely, *barley*, *oats*, *rye*, *wheat*, *rice*, *millet*, and *sorghum*, give the chief character to the agriculture. Here also is the native region of the *olive*, while the *date-palm*, *banana*, *cocoa-nut*, and *bread-fruit*, though their cultivation is not confined to the Old World, afford here the chief subsistence to many millions of the human race. In the New World the *maize*, *arracacha*, *potato*, *manioc*, and *arrow-root*, have their native country. The *banana* is also very extensively cultivated in tropical America, where it is probably indigenous, as it certainly is in the corresponding latitudes of the Old World. The *olive*, originally introduced into Mexico by Cortes, is now largely cultivated on the American Continent, while *sugar*, *coffee*, *tea*, the *vine*, *cocoa*, *pepper*, *cinnamon*, *cassia*, *cloves*, *nutmegs*, and the *potato*, also share, though in very different proportions, the agriculture of both the Old and New Worlds.

The regions over which these plants are distributed may be learned by inspection of Map V. They range from the poles towards the equator in the following order :—

*Barley*, which has the widest distribution of all the *cerealia*, is cultivated from the extreme limits of culture in Lapland, to the heights immediately beneath the equator, but it is only in a little narrow zone of the northern hemisphere that it is reared as the sole bread-corn: beside it appears

*Rye*, which is the peculiar bread-corn in Norway, Sweden, Finland, and Russia, and with it

*Oats*, which are extensively cultivated in Scotland, and generally in Norway, Sweden, and Russia.

*Wheat* is the prevailing cultivated plant in Great Britain and Germany, in France, and in a wide range towards the East, including the whole of the region of the Caspian; in the basin of the Mediterranean, and throughout North America, it is associated with maize.

*Buck-wheat* is a plant of tolerably extensive culture in the northern temperate zone, where it is chiefly used as a green fodder.

*Maize*, or *Indian Corn*, is cultivated to a limited extent in Central Germany and France. In North America it is cultivated more extensively, but in intertropical regions, being aided by the joint influence of heat and moisture, it shoots up luxuriantly, and yields an astonishing produce.

*Rice* has been cultivated in the southern regions of Asia from the earliest ages; it constitutes the staple food of the inhabitants of the Indian peninsula, China, Japan, and the East Indian Islands. This plant, perhaps, nourishes the greatest number of men, and produces within a given space the greatest quantity of nutritious matter.

*Millet* and *Sorghum*.—These cereals, though little productive, are generally cultivated in Africa and India. They are used in a limited extent by the peasants in Italy, especially Tuscany.

*The Olive* in the Old World embraces two zones or bands, north and south of the equator, about 9° in width, from lat. 35° to lat. 44°. The climate of the New World, which is subject to the extremes of heat and cold, is perhaps not so favourable as that of Europe to the culture of this plant. It is, however, now cultivated with considerable success in many parts of America.

*The Date-Palm* yields one of the most nourishing fruits in existence. It grows spontaneously on the southern slopes of the Atlas Chain, on the banks of the Nile, and in the Canary Islands: its range extends to Palestine and Hindoostan, and it has been introduced into the south of Spain. It is said that each tree yields annually from 150 to 260 pounds of fruit.

*The Banana or Plantain*.—This plant which yields a great amount of nutritious substance, is a native of the southern portion of the Asiatic continent, but has been transplanted into the Indian Archipelago and Africa, and has also found its way into the New World, and generally into all tropical countries. The fruits weigh, altogether, about 70 or 80 lbs., and the same space which will bear 1,000 lbs. of potatoes, brings forth, in a much shorter time, 44,000 lbs. of bananas; and if we take account of the nutritious matter which this fruit contains, a surface which, sown with wheat, feeds one man, when planted with bananas affords sustenance to twenty-five. Nothing strikes the European, landing in a tropical country, so much as the little spot of cultivated land round a hut which shelters a very numerous Indian family.

*The Cocoa-nut Palm* also belongs to intertropical climes, flourishing especially on islands and near the sea-shores. It is cultivated nowhere so abundantly as in the islands of Ceylon, Sumatra, and Java.

"It is a tree by far the most important production of nature in the tropics. To the Polynesian it is emphatically the tree of life, transcending even the bread-fruit in the multifarious uses to which it is applied.

"Its very aspect is imposing. Asserting its supremacy by an erect and lofty bearing, it may be said to compare with other trees, as man with inferior creatures.

"The blessings it confers are incalculable. Year after year the islander reposes beneath its shade, both eating and drinking of its fruit; he thatches his hut with its boughs, and weaves them into baskets to carry his food; he cools himself with a fan plaited from the young leaflets, and shields his head from the sun by a bonnet of the leaves; sometimes he clothes himself with the cloth-like substance which wraps round the base of the stalks, whose elastic rods, strung with filberts, are used as a taper; the larger nuts, thinned and polished, furnish him with a beautiful goblet; the smaller ones, with bowls for his pipes; the dry husks kindle his fires; their fibres are twisted into fishing-lines and cords for his canoes; he heals his wounds with a balsam compounded from the juice of the nut; and with the oil extracted from its meat embalms the bodies of the dead.

"The noble trunk itself is far from being valueless. Sawn into posts, it upholds the islander's dwelling; converted into charcoal, it cooks his food; and, supported on blocks of stone, rails in his lands. He impels his canoe through the water with a paddle of the wood, and goes to battle with clubs and spears of the same hard material.

"The fruitfulness of the tree is remarkable. As long as it lives, it bears; and without intermission. Two hundred nuts, besides innumerable white blossoms of others, may be seen upon it at one time; and though a whole year is required to bring any one of them to the germinating point, no two, perhaps, are at one time in precisely the same stage of growth.

"The tree delights in a maritime situation. In its greatest perfection, it is perhaps found right on the sea-shore, where its roots are actually washed. But such instances are only met with upon islands where the swell of the sea is prevented from breaking on the beach by an encircling reef. No saline flavour is perceptible in the nuts produced in such a place. Although it bears in any soil, whether upland or bottom, it does not flourish vigorously inland; and I have frequently observed, that when met with far up the valleys, its tall stem inclines seawards, as if pining after a more genial region.

"The finest orchards of cocoa-palms I know, and the only plantation of them I ever saw at the islands, is one that stands right upon the southern shore of Papeetoe Bay.

"They were set out by the first Pomaree, almost half-a-century ago; and the soil being especially adapted to their growth, the noble trees now form a magnificent grove, nearly a mile in extent. No other plant, scarcely a bush, is to be seen within its precincts. The Broom Road passes through its entire length.

"At noonday this grove is one of the most beautiful, serene, witching places that ever was seen. High overhead are ranges of green rustling arches; through which the sun's rays come down to you in sparkles. You seem to be wandering through illimitable halls of pillars; everywhere you catch glimpses of stately aisles intersecting each other at all points. A strange silence, too, reigns far and near; the air flushed with the mellow stillness of a sunset.

"But after the long morning calms, the sea-breeze comes in, and creeping over the tops of these thousand trees, they nod their plumes. Soon the breeze freshens; and you hear the branches brushing against each other, and the flexible trunks begin to sway. Towards evening, the whole grove is rocking to and fro, and the traveller on the Broom Road is startled by the frequent fallings of the nuts, snapped from their brittle stems. They come flying through the air, ringing like juggler's balls; and often bound along the ground for many rods."—*Melville's Adventures in the South Seas.*

*The Bread-fruit Tree* is distributed generally among the Friendly, the Society, and the Caroline Islands.

*The Cow Tree.*—"Among the many curious phenomena which presented themselves to me in the course of my travels," says Humboldt, "I confess there were few by which my imagination was so powerfully affected as by the cow tree. On the parched side of a rock on the mountains of Venezuela grows a tree with dry and leathery foliage, its large woody roots scarcely penetrating into the ground. For several months in the year its leaves are not moistened by a shower; its branches look as if they were dead and withered; but when the trunk is bored, a bland and nourishing milk flows from it. It is at sunrise that the vegetable fountain flows most freely. At that time, the blacks and natives are seen coming from all parts, provided with large bowls to receive the milk, which grows yellow and thickens at its surface. Some empty their vessels on the spot, while others carry them to their children. One imagines he sees the family of a shepherd who is distributing the milk of his flock."

It is named the *palo de vaca*, or cow tree, and has oblong pointed leaves, with a somewhat fleshy fruit, containing one or sometimes two nuts. When an incision is made in the trunk there issues abundantly a thick glutinous milky fluid, perfectly free from acrimony, and having an agreeable smell. It is drunk by the Negroes and free people who work in the plantations. When exposed to the air, this juice presents on its surface a yellowish cheesy substance, in membranous layers, which are elastic, and in five or six days become sour, and afterwards putrify.

*Batatas*, the *Convolvulus Batatus*, or Spanish potato, is a native of India, but is to a small extent cultivated in Spain and Portugal, and generally in intertropical countries.

The *Yam*, whose great fleshy roots filled with starch, often attain an enormous size, and afford a most important article of food, is cultivated over the whole of the intertropical zone of the Old and New Worlds.

*The Potato.*—This plant which is a native of Chili, was first introduced into Britain from Virginia, by Sir Walter Raleigh, in 1586. Of all the vegetable productions especially adapted for the sustenance of man, it has the widest range, extending, according to Humboldt, from the northern extremity of Africa, to Labrador, Iceland, and Lapland. This, however, must be understood with limitation, as an elevation of at least 4,000 feet seems necessary for its growth in tropical regions.

*Manioc* is a shrub, a native of Brazil. The fleshy root of this plant yields a nutritious food, known under the name of Manioc or Cassava Root, from which we obtain our tapioca.

*Arrow Root* is a native of tropical America; it is so named from the property, it is said to possess, of being an antidote to the poisoned arrows of the Indians. The root of this plant forms a delicate and nourishing article of food.

*Sugar Cane.*—The range of this plant may be said to extend to all the regions of the Torrid Zone. In countries where the mean temperature is not less than 64°, it extends to lat. 30°, on each side of the equator in the New World, and to about lat. 35° or 36° in the Old.

*Coffee.*—This bush or tree is a native of the Ethiopian highlands of Africa, whence it has been introduced into Arabia Felix, the East and West Indian Islands, Surinam, Cayenne, and Brazil.

*Tea* is an evergreen shrub which is extensively cultivated in China, Japan, and Assam; it was first imported into Europe by the Dutch in 1610, and was brought into England in 1666. A species of holly, called Paraguay Tea, grows spontaneously in the forests of Paraguay, and yields a beverage called Matê in Brazil.

*The Vine* comes to perfection in Europe as far north as lat. 50° or 52°, but its profitable culture does not extend much beyond lat. 48°, the best wines being produced between 30° and 45° north latitude. Its range in America is much more limited, a difference of 10° occurring between its northerly limits in the Old and New Worlds.

*Cocoa.*—This tree grows spontaneously in several of the countries of tropical America; its fruit resembles a cucumber, the seeds of which furnish a substance from which chocolate is prepared.

A vast abundance of other plants occur in various parts of the globe, though some of them are not of equal importance with those we have been considering, yet they are highly useful in contributing to the sustenance and comfort of man; amongst these the following may be enumerated:—

*Cotton* is the downy covering of the seeds of a plant which grows spontaneously in intertropical Asia, Africa, and America, and in many countries beyond these limits.

*Pepper*, *Cinnamon*, *Cloves*, and *Nutmegs*, are natives of intertropical regions; their uses are well known. *Cassia* is a species of laurel, and is a native of the islands of the Indian Archipelago.

*Vanilla.*—This delightful aromatic is a native of tropical America; it is used in liqueurs, chocolate, confections, and perfumery.

*Coca*, is a shrub which grows in districts of the Corderillas; its leaves are chewed by the Indians and miners; it has all the deleterious effects of opium.

*Peruvian Bark*, or *Jesuit's Bark*, as it is often called, is extensively used for its medicinal properties; it is yielded by several species of cinchona, whose geographical range is confined to the Cordilleras of Peru and Quito, where they form extensive forests at an elevation of from 1,200 to 10,000 feet above the level of the sea.

# CHAPTER XIV.

## General Laws of the Geographical Distribution of Plants.

It is now universally known that living beings, animals, and plants, are not scattered at random over the surface of the whole globe. Their distribution, on the contrary, is regulated by particular laws which give each country a peculiar aspect. We call climate the physical conditions which seem to regulate this distribution, however diversified the causes thus acting may be. The distribution of heat all the year round; the mode of succession of temperature, either by sudden or gradual changes; the degree of moisture of the atmosphere; the pressure of the air; the amount of light; the electric condition of the atmosphere; all these and perhaps some other agents continually influence the growth of plants and the development of animals. The nature of the soil is no less powerful in its influence upon organized beings, though here also very different agents are considered under one head; as the chemical properties of the ground are evidently as efficient as the physical.

Let us for a moment examine these circumstances. Temperature seems to be the all-ruling power. With the returning smile of spring, vegetation bursts out with new vigour, and dies again as the cold of winter brings back its annihilating rigours. Under the hot sun of the tropics the beauty and variety of vegetation exceed all that is known in more temperate regions, whilst as we approach the polar plains we see it grow gradually less diversified and more dwarfish, thus exhibiting all over the globe a close connection between the modifications of temperature from the equator to the poles, and the geographical distribution of vegetable and animal life. The more powerful influence of temperature upon vegetation does not, however, preclude the influence of other agents; even the manner in which the same amount of heat is distributed over the earth in a given time, will produce differences. It is well known, that countries in which the summers are short but very warm, and the winters very long and cold, have a vegetation totally different from those where the seasons are more equable and succeed each other by gradual changes, although the mean annual temperature of both be the same. Next in importance we may perhaps consider the degree of moisture of the atmosphere, which differs widely in different regions; the damp valleys of the Mississippi, for instance, present the most striking contrast with the rolling country farther west. Again, the swamps and the sandy plains, the rocky hill and the loamy soils, the snow-clad barrens and the frozen gravel of the north, even under circumstances otherwise most similar, afford the greatest diversity of vegetation. There is still another way in which moisture may act in a particular manner; as vegetation is not influenced simply by the annual amount of moisture, but also by the quantity of water that falls at one time, and the periods at which it falls. A low temperature in a moist climate will indeed produce some remarkable peculiarities; for instance, where early winters cause an extensive sheet of snow to be accumulated over the ground, and to protect vegetation from the destroying influence of frost; as in the case in the Alps, where the most delicate flowers prosper admirably under their white blankets, and show themselves in full development as soon as the snow melts away, late in the spring, when the warm season is already fairly set in. Light, again, independently of heat, will also show its influence; shaded places are favourable to plants which would be killed under the more direct influence of the rays of light.

Atmospheric pressure would at first seem to have only a very subordinate influence upon vegetation. But comparing Alpine vegetation with that of higher latitudes, which from their situation must have climates otherwise very similar, we shall be led to the conclusion that atmospheric pressure has its share in bringing about the diversity of plants; for though analogous, the flora of the high north is by no means identical with that of the most elevated Alpine ridges, over which vegetation continues to extend. The influence of atmospheric pressure seems to me particularly evinced in the great, I may say, the prevailing number of Alpine species endowed with a volatile fragrance which adds so much to the sweet and soothing influence of mountain rambles; whilst the northern species, however similar to those of the Alps, partake more or less of the dulness of the heavy sky under which they flourish.

Whatever may be the intensity of other causes, and even when they are most uniform, the chemical nature of the soil acts perhaps as powerfully as the physical conditions under which the plant may grow. To be fully impressed with the important influence of the soil, we need only be familiar with the differences noticed in the growth of wheat or other grains in different soils, or with the different aspect of pastures on rich or poor grounds, and to trace the same modification through any small tract of land, with the view to understand similar changes over wider countries.

To satisfy ourselves of the powerful influence of electricity upon vegetation, we need only remember the increased rapidity with which plants come forth, during spring, after thunder-storms. Many other causes, still more intimately connected with the aspect of our globe, have also a great influence upon the distribution of the animals and plants which live on its surface. The form of continents, the bearing of their shores, the direction and height of mountains, the mean level of great plains, the amount of water circumscribed by land and forming inland lakes or seas, each shows a marked influence upon the general feature of vegetation. Small low islands, scattered in clusters, are covered with a vegetation entirely different from that of extensive plains under the same latitudes. The bearing of the shores again, modifying the currents of the sea, will also react upon vegetation. Mountain chains will be influential not only from the height of their slopes and summits, but also from their action upon the prevailing winds. It is obvious, for instance, that a mountain chain like the Alps, running from east to west, and thus forming a barrier between the colder regions northwards, and the warmer southwards, will have a tendency to lower the temperature of the northern plains, and to increase that of the southern, below or above the mean which such localities would otherwise present; while the influence of a chain running north and south, like the Rocky Mountains and the Andes, will be quite the reverse, and tend to increase the natural differences between the eastern and western shores of the continent, and, laying open the north to southern influences and the south to those of the north, render its climate excessive, that is, its summer warmer and its winter colder.

Again, the equalizing influence of a large sheet of water the temperature of which is less liable to sudden changes than the atmospheric air, is very apparent in the uniformity of coast vegetation over extensive tracts, provided the soil be of the same nature, and also in the slower transition from one season into the other along the shores, the coasts having less extreme temperatures than the main land. The absolute degree of temperature of the water acts with equal power; as the aquatic plants of the tropical regions—for instance, those of Guiana—differ as widely from those of Lake Superior, as the palms differ from the pine forests. But however active these physical agents may be, it would be very unphilosophical to consider them as the source or origin of the beings upon which they show so extensive an influence. However powerful may be the degree of heat, be the air ever so dry or ever so moist, the light ever so moderate or ever so bright, alternating ever so suddenly with darkness, or passing gradually from one condition to the other, these agents have never been observed to produce anything new, or to call into existence anything that did not exist before. Whether acting isolated or jointly, they have never been known even to modify to any great extent the living beings already existing, unless under the guidance and influence of man, as we observe among domesticated animals and cultivated plants. This latter fact shows, indeed, that the influence of the mind over material phenomena is far greater than that of physical forces, and thus refers our thoughts again and again to a supreme intelligence for a cause of all these phenomena rather than to so-called natural agents.

The physical agents whose influence upon organized beings we have just examined, show a regular progression in their action, which agrees most remarkably with the degrees of latitude on one side, and the elevation above the level of the sea on the other. Hence the difference in the vegetation as we proceed from the tropical regions towards the poles, or as we ascend from the level of the sea to any height along the slopes of a mountain. In both these directions there is a striking agreement in the order of succession of the phenomena; so much so, that the natural products of any given latitude may be properly compared with those occurring at a given height above the level of the sea; for instance, the vegetation of regions near the polar circles and that of high mountains near the limits of perpetual snow under any latitude. The height of this limit, however, varies, of course, with the latitude. In Lapland, at 67° north latitude, it is 3,500 feet above the level of the sea; in Norway, at lat. 60°, it is 5,000 feet; in the Alps, at lat. 46°, about 8,500; in the Himalaya, at lat 30°, between 15,000 and 16,000; in Mexico, at lat. 19°, it is 15,000; and at Quito, under the equator, not less than 16,000. At these elevations, in their different respective latitudes, without taking the undulations of the isothermal lines into consideration, vegetation shows a most uniform character, so that it may be said that there is a corresponding similarity of climate and vegetation between the successive degrees of latitude and the successive heights above the sea. As a striking example, I may mention the fact of the occurrence of identical plants in Lapland in lat. 67°, at a height of about 3,000 feet and less above the level of the sea, and upon the summit of Mount Washington, in lat. 44°, at a height of not less than 6,000 feet, while below this limit, in the wooded valleys of the White Mountains, there is not one species which occurs also about North Cape.

There is nevertheless one circumstance which shows that climatic influences alone, however extensive, taking, for instance, into account all the above-mentioned agents together, will not fully account for the geographical distribution of organized beings, as their various limits do not agree precisely with the outlines indicating the intensity of physical agents upon the surface of the earth. A few examples may serve to illustrate this remark. The limit of forest vegetation round the arctic circle does not coincide with the astronomical limits of the arctic zone; nor does it agree fully with the isothermal line of 32° of Fahrenheit; nor is the limit of vegetation in height always strictly in accordance with the temperature, as the *Cerastium latifolium* and *Ranunculus glacialis*, for instance, occur in the Alps as high as ten and even eleven thousand feet above the level of the sea. Again, eastern and western countries within the same continent, or compared from one continent to the other, show such differences under similar climatic circumstances, that we at once feel that something is wanting in our illustrations when we refer the distribution of animals and plants solely to the agency of climate. But the most striking evidence that climate neither accounts for the resemblance nor the difference of animals and plants in different countries may be derived from the fact that the development of the animal and vegetable kingdoms differs widely under the *same* latitudes in the northern and southern hemispheres, and that there are entire families of plants and animals exclusively circumscribed within certain parts of the world; such are, for instance, the magnolia and cactus in America, the kangaroos in New Holland, the elephants and rhinoceros in Asia and Africa, &c., &c. From these facts we may indeed conclude that th are other influences acting in the distribution of animals and plants besides climate; or perhaps we may better put the proposition in this form—that however intimately connected with climate, however apparently dependent upon it, vegetation is, in truth, independent of those influences, at least so far as the casual connexion is concerned, and merely adapted to them. This position would at once imply the existence of a power regulating these general phenomena in such a manner as to make them agree in their mutual connexion; that is to say, we are thus led to consider nature as the work of an intelligent Creator, providing for its preservation under the combined influences of various agents, equally his work, which contribute to their more diversified combinations. The geographical distribution of organized beings displays more fully the direct intervention of a Supreme Intelligence in the plan of the creation than any other adaptation in the physical world. The evidence of such an intervention is derived from the benefits, material, intellectual, and moral, which man derives from nature around him, and from the mental conviction which consciousness imparts to him that there could be no such wonderful order in the creation without an omnipotent Ordainer of the whole.

# CHAPTER XV.

## MAP VI.

### ORDERS OF ANIMAL EXISTENCE.

### I. *Primary Groups of the Animal Kingdom.*

THE arrangement of the animal kingdom proposed by the celebrated naturalist, Cuvier, is that which—with certain modifications rendered necessary by a more extended knowledge of animal structure and affinity—is now generally adopted. The different forms of animal life are distributed into four grand divisions or sub-kingdoms, namely, 1. Vertebrated animals. 2. Molluscous animals. 3. Articulated animals. 4. Radiated animals.

*Vertebrated animals* are those which have a vertebral column or back-bone. This sub-kingdom is subdivided into four classes, 1. Mammalia, or animals which suckle their young. 2. Aves, or Birds. 3. Reptilia, or Reptiles. 4. Pisces, or Fishes.

*Molluscous animals* have no proper skeleton; their bodies are soft, enveloped in a muscular skin or *mantle*, and generally protected by a bivalve or univalve shell. They are divided into six classes, namely:—

1. Cephalopoda (head-footed), so called from having their feet or principal locomotive organs attached to the head, where they form a circle surrounding the mouth: cuttle-fish, nautilus.

2. Gasteropoda (stomach-footed), having the under side of the body so constructed as to form a muscular foot on which the animals creep about: snails, slugs, whelks, limpets.

3. Pteropoda (wing-footed), having a pair of wing-like fins extending outwards from each side of the head: clio, hyalæa.

4. Conchifera (bearing a bivalve shell); these are enclosed in a bivalve shell, their gills are in the form of four leaf-like laminæ: oyster, muscle.

5. Brachiopoda (arm-footed); these are also enclosed in a bivalve shell, but have no special gills; they have two long arms which project from the sides of the mouth, and excite

in the surrounding water currents which bring their food: terebratula, lingula.

6. Tunicata (covered with a tunic); they have no shell, but are enveloped in a sac-like tunic with two openings: ascidians, salpa.

*Articulated animals* have the body composed of a series of segments which succeed each other from before backwards, and are enclosed in a jointed integument, which is frequently hard and supplies the place of a skeleton. This sub-kingdom is divided into eight classes:—

1. Cirrhipoda (tendril-footed), are but obscurely divided into segments, from each of which springs a pair of short feet, bearing two long-jointed tendril-like appendages, which are curled inwards towards the mouth, to which they bring the food: barnacles, acorn-shells.

2. Crustacea (enveloped in a crust or shell), are enclosed in a shelly or horny jointed covering; they are furnished with jointed limbs, and breathe by gills: crab, lobster, shrimp.

3. Arachnida (spider-like), have the body divided into two principal regions; they have eight jointed legs, and the breathing organs are adapted for aërial respiration: spiders, scorpions, mites.

4. Insecta (divided into segments), have the body divided into three principal regions; they have six jointed legs, and the breathing organs are adapted for aërial respiration: beetles, butterflies, flies.

5. Myriapoda (myriad-footed), have the body composed of numerous nearly similar segments; they have numerous jointed legs; the breathing organs are adapted for aërial respiration: centipedes, julus.

6. Annelida (ringed), have the body worm-like and destitute of jointed limbs: nereis, earth-worm, leech.

7. Rotiferæ (wheel-bearers), present but slight traces of division into segments; the head is furnished with wheel-like organs: wheel-animalcules.

8. Entozoa (living within other animals), have a soft, mucous, and colourless skin, and are destitute of special organs of respiration: tape-worm, fluke, ascaris.

*Radiated animals* have a very simple structure, their form is either quite indefinite, or else they possess a more or less star-like shape, caused by the radiated arrangement of the organs around the mouth. The radiated animals are divided into six classes:—

1. Echinodermata (spiny-skinned), have the body more or

less completely protected by calcareous plates imbedded in the skin, and sometimes furnished with spines; the surface is provided with tendril-like suckers used for locomotion: sea-urchins, star-fishes, sea-cucumbers.

2. Acalepha (nettles) have the body composed of a gelatinous and transparent substance; the principal organs are arranged by fours in a radiate manner round the mouth; all the species swim freely in the sea: sea-nettles, jelly-fishes, Portuguese men-of-war.

3. Polypi (many-footed) have the mouth surrounded by a circle of contractile arms or tentacula; they are mostly rooted like a plant, and composed of numerous individuals united into a compound plant-like animal: corals, madrepores, sea-anemones.

4. Infusoria (living in infusions of organic matter) are microscopic animalcules; they are destitute of radiating arms or tentacula, and are without definite members for locomotion. They move about by means of microscopic hair-like appendages (cilia), which are more or less diffused over the surface of the body: vorticella, stentor.

5. Rhozopoda (root-footed) are minute animals of very simple organization, and enclosed in a shell, through perforations in which long root-like prolongations are capable of being protruded: difflugia, vorticialis, nonionina.

6. Amorphozoa (formless animals) are destitute of all definite shape, and consist of the simplest possible structure: amœba, sponge.

### II. *Geographical Distribution of Animals.*

The science of zoology teaches us the nature, properties, and classification of the subjects of the animal kingdom. "Zoological geography treats of the habitats, the limits of distribution and dispersion, of animals as they at present exist, as well as the varieties of animal life considered in relation to external circumstances." In the present chapter we shall consider the distribution of the animal kingdom according to the following groups, beginning with the lowest, and ascending to the highest order of animal life, viz., *radiated animals*, *articulated animals*, *shell-fish*, *fishes*, *reptiles*, *birds*, and *quadrupeds*.

The radiated animals occupy the bottom of the animal scale. The term zoophyte (animal plant) has sometimes been given to them from the resemblance which many of them possess to certain members of the vegetable kingdom.

Among the most interesting families of this group are the various kinds of corals, madrepores, millepores, porites, &c. These all possess an internal solid calcareous axis, invested externally by a living fleshy crust, which is nourished by innumerable mouths or *polypes.* The madrepores, millepores, and porites abound in the tropical seas, and are capable of development only in regions warmed by a vortical sun. It is to their ceaseless energies that we owe those vast reefs and coral islands which extend throughout the Pacific and Indian Oceans. The true corals have a more northern range ; the red coral is found abundantly in the Mediterranean : Sicily in particular has long been famed for its fisheries of this valuable production. Beneath the waters of the Arabian and Persian Gulfs extend vast submarine forests and gardens of corals, and other graceful and gorgeous zoophytes.

*Articulated animals*, of which insects are among the most typical members, are the next in the scale of animal existence; they are distributed through all latitudes, but increase in kinds and in numbers from the poles towards the equator. The *stations* of the articulata are *the sea, the sea-shores, brackish waters, fresh water, various kinds of soil, living vegetables, decomposed vegetables, living animals, dead animals.*

It is amidst the exuberant vegetation of the Torrid Zone that insect life attains its full development. In the tropical regions of Central and South America innumerable quantities of shining flies present at night the appearance of an extensive conflagration. The butterflies of America, of Africa, and of the East Indies are adorned with the most brilliant colours.

*Mollusca or Shell-fish.*—The conchology of the Indian seas is the most splendid, profuse, and varied of any division of the globe ; America and the West Indies are very deficient in species compared with those of Asia in similar latitudes. The shells of the Austral Ocean rank next in splendour to those of the Indian seas. Many species of the shell-fish of the Mediterranean are similar to those of the Red Sea and of the Indian Ocean. The pearl oyster arrives at perfection only in tropical seas. The shell-fish of Northern Europe are not distinguished for their variety or splendour.

*Fishes.*—It is probable that every basin of the ocean has its peculiar tribes, and the regions which some inhabit are well known: thus the cod, which is distributed all over the North Atlantic, congregates chiefly upon the great banks to the south and south-east of Newfoundland. In the Torrid

Zone and its vicinity the most remarkable species of fish are met with. *Sharks*, which are noted for their extreme ferocity, roam in the deep open ocean in tropical and warm climates: the porcupine fish is an inhabitant of warm seas; the saw-fish inhabits the Atlantic Ocean, extending its range across the whole expanse of waters. The sword-fish is found in the Mediterranean, and perhaps extends its range to the coasts of America. The genus *exocetus*, or flying-fish, is met with in all tropical seas, in the Atlantic as well as the Pacific Ocean, and its range extends even into the Mediterranean.

Among the most remarkable of fishes are the *gymnoti* (electric eels), which inhabit several of the rivers and pools in the Llanos of South America: all the inhabitants of the waters dread the society of these animals. The *torpedo*, or cramp-fish, is dispersed over all the seas; but the shocks which it communicates cannot be compared in violence to those of the gymnotus. The migration of fishes is a subject but little understood; it would seem to be occasioned, in some instances at least, by their seeking for shallow water, in order to deposit their spawn.

*Reptiles* are divided into four orders, namely, 1. Batrachia, or frogs, toads, and salamanders; 2. Ophydia, or serpents; 3. Sauria, or lizards and crocodiles; and 4. Chelonia, or turtles and tortoises. They arrive at their full development in the equatorial regions, particularly in tropical America, owing to the combined influence of intense heat, extensive forests, marshes, and rivers. The larger boas belong to the New World, as also the rattle-snakes, of which there are several species; the pythons are confined to Africa and Asia. The crocodile proper inhabits the Nile; the alligator or cayman, America; and the gavial is limited to the Ganges and other Indian rivers. The batrachia are more capable of enduring the extremes of temperature than the other orders of reptiles, and accordingly their range is greater; and although they are larger and more numerous in the warm regions of the earth, they also exist in high and cold latitudes.

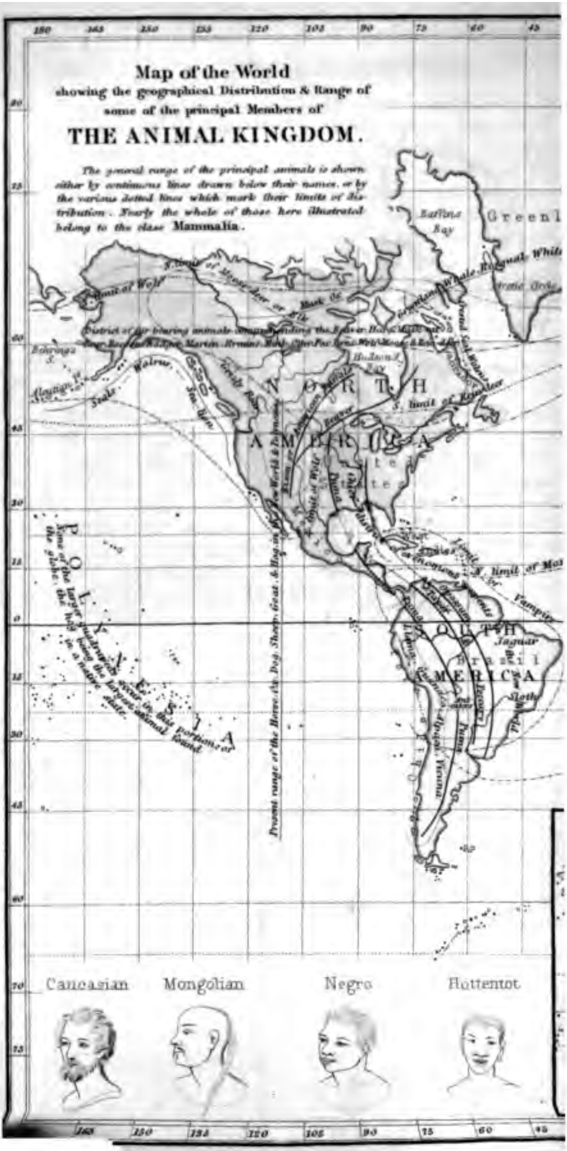
*Birds.*—The Torrid Zone possesses a variety of the most beautiful birds, including the humming-bird of America, the cockatoos, the bird of Paradise, the lories, and several others of the parrot genus. The bird of Paradise is confined to New Guinea and the neighbouring islands. Of the *Struthionidæ*, a family of birds whose imperfectly developed wings incapacitate them for flying, the ostrich inhabits Africa and the

Arabian Desert; the cassowary the peninsula of Malacca and the islands of the Indian Archipelago; the rhea, or South American ostrich, is confined to the plains of South America; while the emis is limited to New Holland and the adjacent islands; and the apteryx, one of the most singular of existing birds, has never been met with beyond the shores of New Zealand. The albatross is seen skimming the surface of the ocean as we approach the 40th parallel. The condor, which frequently soars to an elevation of four miles, never forsakes the chain of the Cordilleras of Peru and Mexico. The frozen zones have their own kinds of birds, among which are owls, ducks, and other aquatic birds; the great snowy owl is the most characteristic bird of Arctic Europe. The jer-falcons of Norway and Iceland, perfect models of symmetry and strength, and among the most characteristic and vigorous of all the birds of prey, are quite unknown, not only within the tropics, but even in the temperate latitudes, excepting upon the summits of mountains, where the climate is cold.

*Mammalia*, or mammiferous quadrupeds: these stand at the head of the animal creation, and are distributed into ten great groups; though they differ vastly in appearance and habits, they nevertheless correspond in one particular, that of suckling their young. The groups, with some of their types, are as follow:—

1. Quadrumana (four-handed): monkeys, apes. 2. Cheiroptera (hand-winged): bats, flying lemurs. 3. Carnivora (flesh-eaters): cat, lion, tiger, hyæna, dog, bear, civet, weasel, otter, seal. 4. Rodentia (gnawers): beaver, porcupine, squirrel, hare, jerboa. 5. Edentata (toothless): sloth, armadillo, ant-eater. 6. Ruminantia (chewing the cud): camel, ox, goat, sheep, deer, antelope, giraffe. 7. Pachydermata (thick-skinned): elephant, rhinoceros, hippopotamus, horse, ass, boar, tapir. 8. Cetacea (whale-like): whale, dolphin, narwhal, porpoise, dugong. 9. Marsupialia (pouched): opossum, kangaroo, wombat. 10. Monotremata (single outlet): ornithorynchus, echidna.

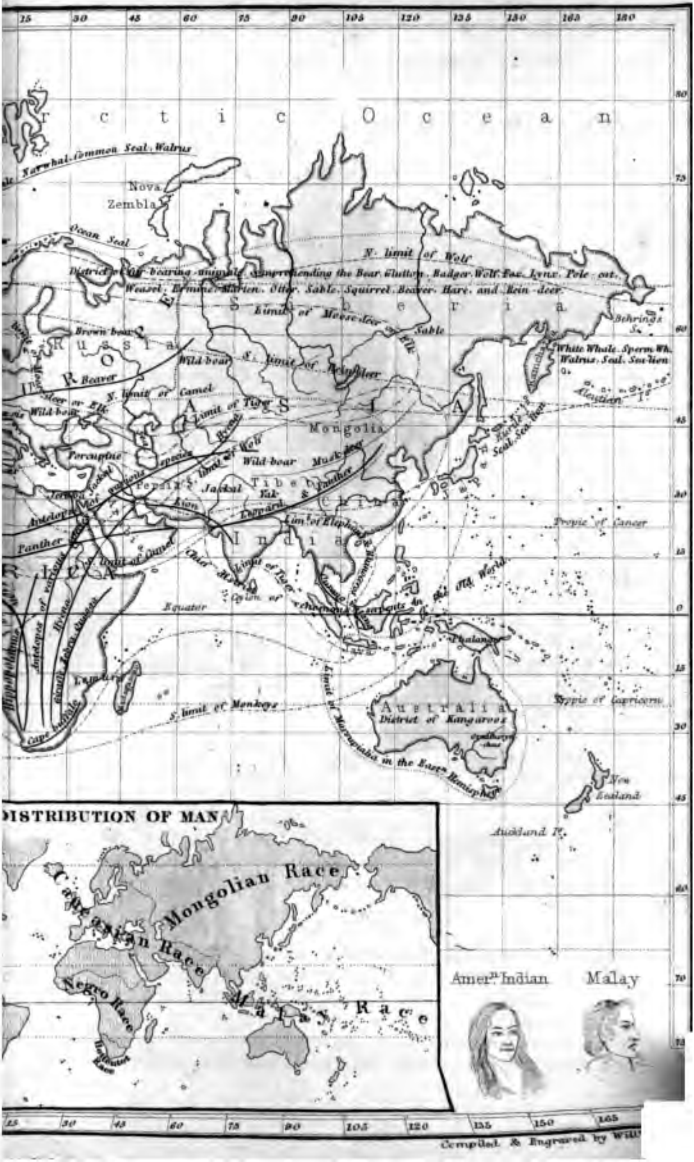
The ranges of these animals are laid down on the Map, upon which they can be studied with more advantage than from any description.



# Map of the World
showing the geographical Distribution & Range of
some of the principal Members of

# THE ANIMAL KINGDOM.

*The general range of the principal animals is shown either by continuous lines drawn below their names, or by the various dotted lines which mark their limits of distribution. Nearly the whole of those here illustrated belong to the class* **Mammalia**.



Compiled & Engraved by Will

# CHAPTER XVI

## MAP VI.

### GEOGRAPHICAL DISTRIBUTION OF MAN.

MAN, the Lord of Creation, has the whole earth for his abode. The physical capabilities of his frame fit him for every variety of climate, soil, and situation; and, being capable of deriving nourishment from all kinds of food, his habitations extend to the remotest confines of animated nature. Under the scorching rays of a tropical sun, upon the banks of the Senegal, the human body supports a heat which causes spirits of wine to boil; and in the polar regions of north-east Asia it resists a cold which freezes mercury.

On this fact Dr. Paley remarks: "The human animal is the only one which is naked, and the only one which can clothe itself. This is one of the properties which renders him an animal of all climates, and of all seasons. He can adapt the warmth or lightness of his covering to the temperature of his habitation. Had he been born with a fleece upon his back, although he might have been comforted by its warmth in high latitudes, it would have oppressed him by its weight and heat as the species spread towards the equator."

Within the tropics, where a vegetable diet is found to be most grateful and conducive to health, nature supplies, in the greatest abundance, the most valuable vegetable productions. In the temperate regions, animal food is more or less abundant; and the various kinds of grain, roots, and fruit afford plentiful and wholesome nutriment. As we approach the polar regions, grains and fruit gradually disappear, and animal food becomes more and more exclusively used, until we reach the Samoieds and Esquimaux, who are unacquainted with bread.

### I. *Races of Men.*

*The Sacred Scriptures*, whose testimony is received by all men of unclouded minds with implicit and reverential assent, declare that it pleased the Almighty Creator to make of one blood all the nations of the earth, and that all mankind are the offspring of common parents. But there are writers in the present day who maintain that this assertion does not comprehend the uncivilized inhabitants of remote regions; and that Negroes, Hottentots, Esquimaux, and Australians, are not, in fact, men in the full sense of that term, or beings endowed with like mental faculties to ourselves. Some of these writers contend, that the races above mentioned, and other rude and barbarous tribes, are inferior in their original endowments to the human family which supplied Europe and Asia with inhabitants, and that they are organically different, and can never be raised to an equality, in moral and intellectual powers, with the offspring of that race which displays in the highest degree all the attributes of humanity.

"The expression *races*, however applied to man," to use the language of Frederick Von Schlegel,* "involves something abhorrent from his high uplifted spirit, and debasing to his native dignity. This diversity of races among men no one ought to exaggerate in a manner so as to raise doubts as to the identity of their origin; for, according to a general organic law, which, indeed, is allowed to hold good in the natural history of animals, races capable of a prolific union must be considered of the same origin, and as constituting the same species. Even the apparent chaos of different languages may be classed into kindred families; which, though separated by the distance of half the globe, seem still very closely allied. Of these different families of tongues, the first and most eminent are those which by their internal beauty, and the noble spirit breathing through them, and apparent in their whole construction, denote for the most part a higher origin and a divine inspiration; and, much as all the languages differ from each other, they appear after all, to be merely branches of one common stem. When man had once fallen from virtue, no determinable limit could be assigned to his degradation, nor how far he might descend by degrees, and approximate even to the level of the brute; for, as from his origin, he was a being essentially free, he was, in consequence, capable of change, and even in his organic powers most flexible."

A classification of mankind is based upon the differences that exist in respect of the colour of the skin, hair, and eyes, and the form of the skull. Dr. Pritchard, in his work entitled "The Natural History of Man," arranges the inhabitants of the globe into three great classes, according to the colour of the hair, namely:—

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* 'Philosophy of History.'

The *Melanic*, or black class, includes all individuals or races who have black hair.

The *Xanthous*, or fair class, comprises those who have brown, auburn, yellow, flaxen, or red hair.

The *Albino*, or white variety, comprises those whose hair is pure white, and who have also red eyes.

The classification of Blumenbach, however, is that which has been most generally adopted. From observations made upon the form of the skull, that distinguished naturalist has arranged mankind into *five* classes:—1. *The Caucasian.* 2. *The Mongolian.* 3. *The Ethiopic.* 4. *The American.* 5. *The Malay.*

1. *In the Caucasian race*, the head is of the most symmetrical shape, almost round; the forehead of moderate extent; the cheek-bones rather narrow, without any projection, but having a direction downwards from the malar process of the frontal bone; the aveolar edge well rounded; the front teeth of both jaws placed perpendicularly; the face is of an oval shape, and straight; the features moderately prominent; the forehead arched; nose narrow, and slightly arched, or at least with the bridge somewhat convex; mouth small, with the lips slightly turned out, particularly the lower one; chin full and round. The Caucasians are of all complexions, from the Hindoos and Arabs (some of whom are as black as African Negroes) to the Danes, Swedes, and Norsemen, who are fair, with flaxen hair and light blue eyes. In this class are comprised the ancient and modern inhabitants of Europe (except the Laplanders and Finns), the ancient and modern inhabitants of Western Asia as far as the Obi, the Beloor-tagh, and the Ganges, such as the Assyrians, Babylonians, Medes, and Persians, Sarmatians, Scythians, Parthians, Jews, Arabs, and Syrians, the Turks and Tartars, properly so called, the tribes of Caucasus, the Armenians, Persians, Affghans, and Hindoos; the Africans who live on the shores of the Mediterranean Sea and throughout the Sahara, the Egyptians and Copts, the Abyssinians, and the Guanches, or ancient people of the Canary Islands.

To these we need hardly add the European colonists who have settled in America and other parts of the world. The complexion of this class of people seems to depend very much upon climate and the degree of solar heat to which they are exposed; for they are all, without exception, born with light complexions, and become dark only as they grow up, and are more exposed to the sun. Their colour is found to deepen by regular gradation, from the furthest north, where the people of this race are very fair, through the olive-coloured people of the south of France, and of Spain, Portugal, Italy, Greece, and the swarthy Moors, till the gradation ends with the deep black natives of the African and Arabian deserts, and of intertropical India. White seems to be the characteristic of the race; but it is everywhere subject to the influence of climate. The Caucasians are therefore properly enough called the White Race, though some of them are perfectly black. Their hair, whether Melanic or Xanthous, is always long and flowing, and never woolly, like that of the Negroes.

2. *The Mongolian class* has the head almost square; the cheek-bones projecting; the nose flat; the nasal bones and the space between the eyebrows nearly on the same horizontal plane with the cheek-bones; the arches of the eyebrows scarcely to be perceived; the nostrils narrow; the chin slightly prominent; the face is broad and nose flat; the parts imperfectly distinguished; cheeks projecting, round, and narrow; the linear opening of the eyelids extending towards the temples; the inner corner of the eye sunk towards the nose, and the upper eyelid at that part continued into the lower by a rounded sweep; the complexion is generally olive, which is sometimes very slight, and approaching to yellow, or what is called sallow, and none of this class are known to be of a fair complexion; the iris of their eyes is black; their hair black, straight, and strong, but seldom curled or in great abundance, and they have little or no beard. In this class are comprised the numerous tribes that occupy the central, north-east, east, and south-east parts of Asia, the Chinese and Japanese, the people of Tibet, Bootan, and Indo-China, the Finns and the Laplanders of the north of Europe, and the Esquimaux, who live along the shores of the Polar Sea, in America, and Greenland. The colour of this class is influenced in a slight degree by climate; those of them, and those parts of the body, most exposed to the sun and the air, being the darkest.

3. *The Ethiopic* or *Black race* has the head narrow, and compressed at the sides; the forehead very convex and vaulted; the cheek-bones projecting; the nostrils wide; the jaws long; the front teeth of the upper jaw turned obliquely forward; the lower jaws strong and large; the skull generally thick and heavy; the face is narrow, with the lower part projecting; eyes prominent; nose spread, and almost confounded with the cheeks; the lips, particularly the upper one, very thick; the jaws prominent, and the chin retracted; the skin and the iris of the eye are deep black; the hair black and woolly. In this class are comprised all the natives of Africa to the south of the Sahara and Abyssinia; also the natives of Australia, Van Diemen's Land or Tasmania, Papua or New Guinea, New Britain, the Solomon Isles, New Georgia, the New Hebrides, New Caledonia, the Feejee Islands, and also various tribes throughout the Indian archipelago.

4. *The American class* approaches the Mongolian. The cheek-bones are prominent, but more arched and rounded than in the Mongol, without being so angular or projecting at the sides; the orbits almost always deep; the shape of the forehead and the crown often artificially modified; the skull generally light; the face is broad without being flat; the features, viewed in profile, are prominent and deeply marked; the forehead low; eyes deep-seated; nose rather flat, but prominent; the skin is red, more or less dark or copper-coloured, and approaching to black, according to climate and other circumstances; the hair is like that of the Mongolian class, and they have little or no beard. In this class are comprehended all the native American tribes and nations, excepting, of course, the Esquimaux and the descendants of European and African colonists.

5. *The Malay class* has the top of the head slightly narrowed; the forehead a little arched; the cheek-bones not prominent; the upper jaws a little pushed forward; the prominence of the parietal bones strongly marked; the face is less narrow than that of the Negro, somewhat advancing in the lower part when seen in profile; the features generally more prominent than those of the Negro; the nose full, broad, and thick towards the point, or what is called a bottle nose; the colour of the skin is brown or tawny; the hair black, soft, curled, and abundant. In this class are comprised all the natives of the islands of the Pacific Ocean (excepting those already mentioned as belonging to the Ethiopic class), likewise the dominant nations of the Indian archipelago.

It may be remarked that the Europeans, a branch of the Caucasian race, are distinguished for their advanced state of civilization, their superior intellectual powers, as evinced in their enterprise, invention, perseverance, and power of combination, and for the vast influence they exert over their fellow-creatures throughout other parts of the globe: the European is master of nearly the whole of the Western World, whilst in Asia some of the oldest, most extensive, and richest countries are in his power, and he has founded settlements in Africa and Australia, that will, no doubt, spread over the habitable portions of those vast regions. It is a remarkable trait in his character, that he never rests satisfied with what he has achieved, but is always pressing forward with ardour in the career of industry and invention, and is at this moment as anxious to advance himself as his ancestors were centuries ago.

# CHAPTER XVII.

## GENERAL LAWS OF THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

No animal, excepting man, inhabits all parts of the surface of the earth. Each great geographical or climatal region is occupied by some species not found elsewhere; and each animal dwells within certain limits, beyond which it does not range while left to its natural freedom, and within which it always inclines to return, when removed by accident or design. Man alone is a cosmopolite. His domain is the whole earth; for him, and with a view to him, it was created; his right to it is based upon his organization and relation to Nature, and is maintained by his intelligence and the perfectibility of his social condition.

A group of animals which inhabits any particular region, embracing all the species, both aquatic and terrestrial, is called its Fauna, in the same manner as the plants of a country are called its Flora. To be entitled to this name, it is not necessary that every animal in the group should be different from those inhabiting any other region; it is sufficient that there should be peculiarities in the distribution of the families, genera, and species, and in the preponderance of certain types over others, sufficiently prominent to impress upon the group well-marked features. Thus, for example, in the islands of the Pacific are found terrestrial animals, altogether peculiar, and not found on the nearest continents. There are numerous animals in New Holland differing from any found on the continent of Asia, or, indeed, on any other part of the earth. If, however, some species inhabiting both shores of a sea which separates two terrestrial regions are found to be alike, we are not to conclude that those regions have the same fauna, any more than that the flora of Lapland and England are alike, because some of the sea-weeds found on both shores are the same.

There is an evident relation between the fauna of any locality and its climate: and, on that account, the faunas of the two hemispheres have been distributed into three principal divisions, namely, the arctic, the temperate, and the tropical faunas, in the same manner as we have arctic, temperate, and tropical floras. Hence, also, animals dwelling at high elevations, upon mountains where the temperature is much reduced, resemble the animals of colder latitudes rather than those of the surrounding plains.

In some respects, the peculiarities of the fauna of a region depend upon its flora, at least so far as land animals are concerned; for herbivorous animals will exist only where there is an adequate supply of vegetable food. But taking the terrestrial and aquatic animals together, the distribution of a fauna is less intimately dependent on climate than that of a flora. Plants, in truth, are for the most part terrestrial (marine plants being relatively very few), while animals are chiefly aquatic. The ocean is the true home of the animal kingdom; and while plants, with the exception of the lichens and mosses, become dwarfed or perish under the inflence of severe cold, the sea teems with animals of all classes, far beyond the extreme limit of flowering plants.

The influence of climate, in the polar regions, acts merely to induce a greater uniformity in the species of animals. Thus, the same animals inhabit the polar regions of the three continents. The polar bear is the same in Europe, Asia, and America, and so are also a great many birds. In the temperate regions, on the contrary, the species differ on each of the continents, but they still preserve the same general features. The types are the same, but they are represented by different species. In consequence of these general resemblances, the first colonists of New England erroneously applied the names of European species to American animals. Similar differences are observed as to regions of the same continent, within the same parallels of latitude. The animals of Oregon and of California are not the same as those of New England. The difference, in certain respects, is even greater than between the animals of New England and Europe, as the researches of the naturalists of the United States' Exploring Expedition have proved. In like manner, the animals of temperate Asia differ more from those of Europe than they do from those of America.

Under the torrid zone, the animal kingdom, as well as the vegetable, attains its highest development. The animals of the tropics are not only different from those of the temperate zone, but, moreover, they present the greatest variety among themselves. The most gracefully proportioned forms are found by the side of others the most odd, decked with every combination of the most brilliant colouring. At the same time, the contrast between the animals of different continents is more marked; and, in many respects, the animals of the different tropical faunas differ not less among themselves than they do from those of the temperate or frozen zones. Thus, the fauna of Brazil is quite as different from that of Central Africa as it is from that of the United States.

This diversity upon different continents cannot depend simply on any influence of the climate of the tropics; if it were so, uniformity ought to be restored in proportion as we recede from the tropics towards the antarctic temperate regions. But, instead of this, the differences continue to increase; so much so, that no faunas are more in contrast than those of Cape Horn, the Cape of Good Hope, and New Holland. Hence other influences must be in operation besides those of climate—influences of a higher order, which are involved in a general plan, and intimately associated with the development of life on the surface of the earth.

Faunas are more or less distinctly limited, according to the natural features of the earth's surface. Sometimes two faunas are separated by an extensive chain of mountains, like the Rocky Mountains. Again, a desert may intervene, like the desert of Sahara, which separates the fauna of Central Africa from that of the Atlas and and the Moorish coast, the latter of which is merely an appendage to the fauna of Europe. But the sea effects the most complete separation. The depths of the ocean are quite as impassable for marine species as high mountains are for terrestrial animals. It would be quite as difficult for a fish or a mollusk to cross from the coast of Europe to the coast of America, as it would be for a reindeer to pass from the arctic to the antarctic regions, across the torrid zone. Experiments of dredging in very deep water have also taught us that the abyss of the ocean is nearly a desert. Not only are no materials found there for sustenance, but it is doubtful if animals could sustain the pressure of so great a column of water, although many of them are provided with a system of pores, which enables them to sustain a much greater pressure than terrestrial animals.

When there is no great natural limit, the transition from one fauna to another is made insensibly. Thus, in passing from the arctic to the temperate regions of North America, one species takes the place of another, a third succeeds the second, and so on, until finally the fauna is found to be an entirely new one, without its being always possible to mark the precise limit between the two.

The range of species does not at all depend upon their powers of locomotion; if it were so, animals which move slowly and with difficulty would have a narrow range, whilst those which are very active would be widely diffused. Precisely the reverse of this is actually the case. The common oyster extends at least from Cape Cod to the Carolinas; its range is consequently very great, much more so than that of some of the fleet animals, as, for instance, the Moose. It is even probable that the very inability of the oyster to travel really contributes to its diffusion, inasmuch as being once removed, it is difficult for it to return; and, moreover, being fixed, and consequently unable to choose positions for its eggs, they must be left to the mercy of currents; while Fishes, by depositing their eggs in the bays and inlets of the shore, undisturbed by currents and winds, secure them from too wide a dispersion.

The nature of their food has an important bearing upon the grouping of animals, and upon the extent of their distribution. Carnivorous animals are generally less confined in their range than herbivorous ones, because their food is almost everywhere to be found. The herbivora, on the other hand, are restricted to the more limited regions corresponding to the different zônes of vegetation. The same remark may be made with respect to Birds. Birds of prey, like the eagle and vulture, have a much wider range than the granivorous and gallinaceous birds. Still, notwithstanding the facilities they have for change of place, even the birds that wander widest recognise limits which they do not overpass. The Condor of the Cordilleras does not descend into the temperate regions of the United States; and yet it is not that he fears the cold, since he is frequently known to ascend even above the highest summits of the Andes, and disappears from view where the cold is most intense; nor can it be from lack of prey.

Again, the peculiar configuration of a country sometimes determines a peculiar grouping of animals into what may be called local faunas. Such, for example, are the Prairies of the West, the Pampas of South America, the Steppes of Asia, the Deserts of Africa; and for marine animals, the basin of the Caspian. In all these localities, animals are met with which exist only there, and are not found except under those particular conditions.

Finally, to obtain a true picture of the zoological distribution of animals, not the terrestrial types alone, but the marine species must also be included. Notwithstanding the uniform nature of the watery element, the animals which dwell in it are not dispersed at random; and though the limits of the marine may be less easily defined than those of the terrestrial fauna, still marked differences of the animals in the great basins are not less observable. Properly to apprehend how marine animals may be distributed into local faunas, it must be remembered that their residence is not in the high sea, but along the coasts of continents and on soundings. It is on the Banks of Newfoundland, and not in the deep sea, that the great cod-fishery is carried on; and it is well known that when fishes migrate, they take care to run along the shores. The range of marine species being, therefore, confined to the vicinity of the shores, their distribution must be subjected to laws similar to those which regulate the terrestrial faunas. As to the fresh-water fishes, not only do the species vary in the different zones, but even the different rivers of the same region have species peculiar to them, and not found in neighbouring streams.

A very influential cause in the distribution of aquatic animals is the depth of the water. The Mollusks, and even the Fishes found near the surface between high and low water differ, in general, from those living at the depth of twenty or thirty feet, and these again are found to be different from those which are met with at a greater depth. Their colouring, in particular, varies, according to the quantity of light they receive, as has also been shown to be the case with the marine plants.

It is sometimes the case that one or more animals are found upon a certain chain of mountains, and not elsewhere; as, for instance, the Mountain Sheep (*Ovis montana*), upon the Rocky Mountains, or the Chamois and the Ibex upon the Alps. The same is also the case on some of the wide plains or prairies. This, however, does not entitle such regions to be considered as having an independent fauna, any more than a lake is to be regarded as having a peculiar fauna, exclusive of the animals of the surrounding country, merely because some of the species found in the lake may not ascend the rivers emptying into it. It is only when the whole group of animals inhabiting such a region has such peculiarities as to give it a distinct character, when contrasted with animals found in surrounding regions, that it is to be regarded as a separate fauna. Such, for example, is the fauna of the great steppe or plain of Gobi, in Asia; and such, indeed, that of the chain of the Rocky Mountains may prove to be, when the animals inhabiting them are better known.

The migration of animals might at first seem to present a serious difficulty in determining the character or the limits of a fauna ; but this difficulty ceases if we regard the country of an animal to be the place where it makes its habitual abode. As to Birds, which of all animals wander the farthest, it may be laid down as a rule, that they belong to the zone in which they breed. Thus, the gulls, many of the ducks, mergansers, and divers, belong to the boreal regions, though they pass a portion of the year with us. On the other hand, the swallows and martins, and many of the gallinaceous birds, belong to the temperate faunas, notwithstanding they migrate during winter to the confines of the torrid zone. This rule does not apply to the fishes, who annually leave their proper home, and migrate to a distant region merely for the purpose of spawning. The salmon, for example, comes down from the North to spawn on the coasts of Maine and Nova Scotia, and in the British rivers and the rivers of Western Europe.

Few of the Mammals, and these mostly of the tribe of Rodents, make extensive migrations. Among the most remarkable of these are the Kamtschatka rats. In Spring they direct their course westward, in immense troops ; and after a very long journey, return again in Autumn to their quarters, where their approach is anxiously awaited by the hunters, on account of the fine furs to be obtained from the numerous carnivora which always follow in their train. The migrations of the Lemmings are marked by the devastations they commit along their course, as they come down from the borders of the Frozen Ocean to the valleys of Lapland and Norway ; but their migrations are not periodical.

## Distribution of the Faunas.

We have stated that all the faunas of the globe may be divided into three departments, corresponding to as many great climatal divisions, namely, the glacial or arctic, the temperate and the tropical faunas. These three divisions appertain to both hemispheres, as we recede from the equator towards the north or south poles. It will hereafter be shown that the tropical and temperate faunas may be again divided into several zoological provinces, depending on longitude or on the peculiar configuration of the continents.

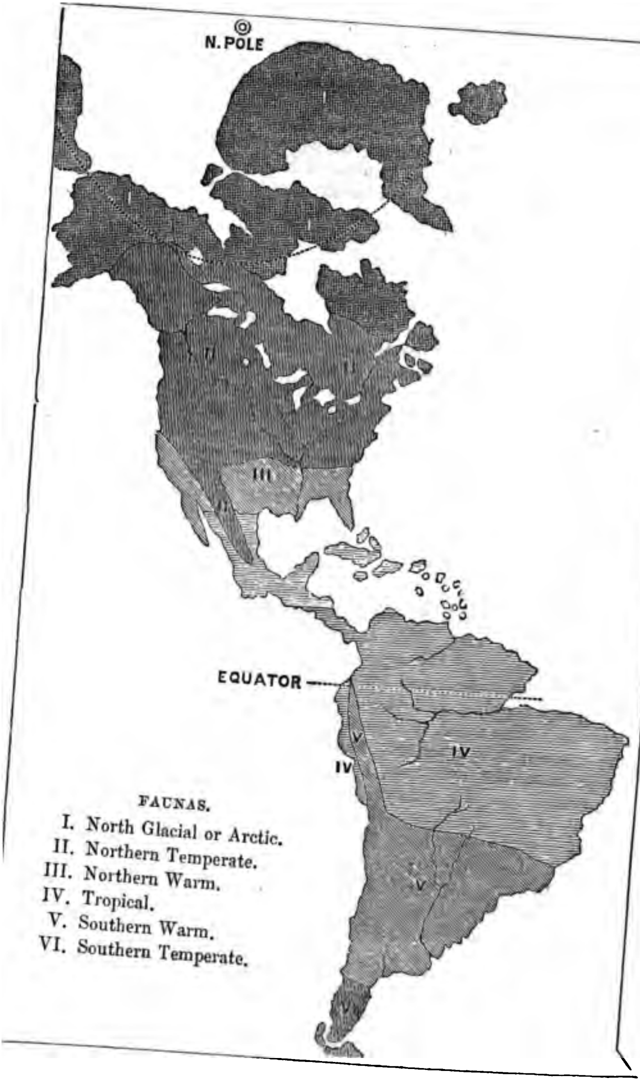
No continent is better calculated to give a correct idea of distribution into faunas, as determined by climate, than the continent of America; extending as it does across both hemispheres, and embracing all latitudes, so that all climates are represented upon it, as shown by the chart on the next page.

Let a traveller embark at Iceland, which is situated on the borders of the polar circle, with a view to observe, in a zoological aspect, the principal points along the eastern shore of America. The result of his observation will be very much as follows:—Along the coast of Greenland and Iceland, and also along Baffin's Bay, he will meet with an unvaried fauna composed of the same animals, which are also for the most part identical with those of the arctic shores of Europe. It will be nearly the same along the Labrador coast.

As he approaches Newfoundland, he will see the landscape, and with it the fauna, assuming a somewhat more varied aspect. To the wide and naked or turfy plains of the boreal regions succeed forests, in which he will find various animals which dwell only in forests. Here the temperate fauna commences. Still the number of species is not yet very considerable; but as he advances southwardly, along the coasts of Nova Scotia and New England, he finds these species gradually increasing, while those of the cold regions diminish, and at length entirely disappear, some few accidental or periodical visiters excepted, who wander, during winter, as far south as the Carolinas.

But it is after having passed the boundaries of the United States, among the Antilles, and more especially on the southern continent, along the shores of the Orinoco and the Amazon, that our traveller will be forcibly struck with the astonishing variety of the animals which people the forests, the prairies, the rivers, and the sea-shores, most of which he will also find to be different from those of the northern continent. By this extraordinary richness of new forms, he will become sensible that he is now in the domain of the tropical fauna.

Let him still travel on beyond the equator towards the tropic of Capricorn, and he will again find the scene change as he enters the regions where the sun casts his rays more obliquely, and where the contrast of the seasons is more


N. POLE
I
II
I
III
II
EQUATOR
V
IV
IV
V
VI
FAUNAS.
I. North Glacial or Arctic.
II. Northern Temperate.
III. Northern Warm.
IV. Tropical.
V. Southern Warm.
VI. Southern Temperate.

marked. The vegetation will be less luxuriant; the palms will have disappeared to make place for other trees; the animals will be less varied; and the whole picture will recall to him, in some measure, what he witnessed in the United States. He will again find himself in the temperate regions, and this he will trace on till he arrives at the extremity of the continent, the fauna and the flora becoming more and more impoverished as he approaches Cape Horn.

Finally, we know that there is a continent around the South Pole. Although we have as yet but very imperfect notions respecting the animals of this inhospitable clime, still the few which have already been observed there, all present a close analogy to those of the arctic region. It is another glacial fauna, namely, the antarctic. Having thus sketched the general distribution of the fauna, it remains to point out the principal features of each of them.

### I. *Arctic Fauna.*

The predominant feature of the Arctic Fauna is its uniformity. The species are few in number; but, on the other hand, the number of individuals is immense. We need only refer to the clouds of birds which hover upon the islands and shores of the north; the shoals of fishes, the salmon among others, which throng the coasts of Greenland, Iceland, and Hudson's Bay. The same uniformity appears in the form and colour of the animals. There is not a single bird of brilliant plumage, and not a fish with varied hues. Their forms are regular, and their tints as dusky as the northern heavens. The most conspicuous animals are the white bear, the moose, the reindeer, the musk-ox, the white fox, the polar hare, the lemming, and various seals; but the most important are the whales, which, it is to be remarked, rank lowest of all the Mammals. Among the Birds may be enumerated some sea-eagles and a few waders, with an immense number of other aquatic species, such as gulls, cormorants, divers, petrels, ducks, geese, &c., all belonging to the lowest order of birds. Reptiles are altogether wanting. The Articulata are represented by numerous marine worms, and by minute crustaceans.

This assemblage of animals is evidently inferior to that of other faunas, especially to those of the tropics. Not that there is a deficiency of animal life; for if the species are less numerous, there is a compensation in the multitude of individuals, and also in this other very significant fact, that the largest of all animals, the whales, belong to this fauna.

It has already been said that the arctic fauna of the three continents is the same; its southern limit, however, is not a regular line. It does not correspond precisely with the polar circle, but rather to the isothermal zero, that is, the line where the average temperature of the year is at 32° of Fahrenheit. The course of this line presents numerous undulations. In general, it may be said to coincide with the appearance of trees, so that it passes where forest vegetation succeeds the vast arid plains, the barrens of North America, or the *tundras* of the Samoiedes. The uniformity of these plains involves a corresponding uniformity of plants and animals. On the North American continent it extends much further southward on the eastern shore than on the western. From the peninsula of Aliaska it bends northwards towards the Mackenzie, then descends again towards the Bear Lake, and comes down to near the northern shore of Newfoundland.

### II. *Temperate Faunas.*

The faunas of the temperate regions of the northern hemisphere are much more varied than that of the arctic zone. Instead of consisting mainly of aquatic tribes, we have a considerable number of terrestrial animals of graceful form, animated appearance, and varied colours, though less brilliant than those found in tropical regions. Those parts of the country covered with forests especially swarm with insects, worms, terrestrial and fluviatile mollusks, which again become the food of other animals.

Still, the climate is not sufficiently warm over the whole extent of this zone to allow the trees to retain their foliage throughout the year. At its northern margin the leaves, excepting those of the pines and spruces, fall, on the approach of the cold season, and vegetation is arrested for a longer or shorter period. Insects retire, and the animals which live upon them no longer find nourishment, and are obliged to migrate to warmer regions, on the borders of the tropics, where, on the ever-verdant vegetation, they find the means of subsistence.

Some of the herbivorous Mammals, the bats, and the reptiles which feed on insects, pass the winter in a state of torpor, from which they awake in spring. Others retire into dens, and live on the provisions they have stored up during the warm season. The Carnivora, the Ruminants, and the most active portion of the Rodents, are the only animals that do not change either their abode or their habits. The fauna of the temperate zone thus presents an ever-changing picture, which may be considered as one of its most important features, since these changes recur with equal constancy in the Old and the New World.

Taking the contrast of the vegetation as a basis, and the consequent changes of habit imposed upon the denizens of the forests, the temperate fauna has been divided into two regions,—a northern one, where the trees, except the pines, drop their leaves in winter, and a southern one, where they are evergreen. Now, as the limit of the former, that of the deciduous trees, coincides, in general, with the limit of the pines, it may be said that the cold region of the temperate fauna extends as far as the pines. In the United States this coincidence is not so marked as in other regions, inasmuch as the pines extend into Florida, while they do not prevail in the Western States; but we may reckon as belonging to the southern portion of the temperate region that part of the country south of the latitude where the Palmetto or Cabbage-tree (*Chamærops*) commences, namely, all the States to the south of North Carolina, while the States to the north of this limit belong to the northern portion of the temperate region.

A peculiar characteristic of the faunas of the temperate regions in the northern hemisphere, when contrasted with those of the southern, is the great similarity of the prevailing types on both continents. Notwithstanding the immense extent of country embraced, the same stamp is everywhere exhibited. Generally, the same families, frequently the same genera, represented by different species, are found. There are even a few species of terrestrial animals regarded as identical on the continents of Europe and America; but their supposed number is constantly diminished, as more accurate observations are made. The predominant types among the mammals are the bison, deer, ox, horse, hog, numerous rodents, especially squirrels, and hares, nearly all the insectivora, weasels, martens, wolves, foxes, wild cats, &c. On the other hand, there are no Edentata and no Quadrumana, with the exception of some monkeys on the two slopes of the Atlas. Among Birds, there is a multitude of climbers, passerine, gallinaceous, and many rapacious birds. Of Reptiles, there are lizards and tortoises of small or medium size, serpents, and many batrachians, but no crocodiles. Of Fishes, there are the trout family, the sturgeons, the pikes, the cod, and especially the great family of herrings and scomberoids, to which latter belong the mackerel and the tunny. All classes of the Mollusks are represented, as well as numerous Polyps, though the corals proper do not yet appear abundantly.

On each of the two continents of Europe and America, there is a certain number of species which extend from one extreme of the temperate zone to the other. Such, for example, are the deer, the bison, the cougar, the flying squirrel, numerous birds of prey, several tortoises, and the rattlesnake, in America. In Europe, the brown bear, wolf, swallow, and many birds of prey. Some species have a still wider range, like the ermine, which is found from Behring's Straits to the Himalaya mountains, that is to say, from the coldest regions of the arctic zone to the southern confines of the temperate zone. It is the same with the musk-rat, which is found from the mouth of Mackenzie's River to Florida. The field-mouse has an equal range in Europe. Other species, on the contrary, are limited to one region.*

In America, as in the Old World, the temperate fauna is further subdivided into several districts, which may be regarded as so many zoological provinces, in each of which there is a certain number of animals differing from those in the others, though very closely allied. Temperate America presents us with a striking example in this respect. We have, on the one hand:—

1st. The fauna of the United States, properly so called, on this side of the Rocky Mountains.

2nd. The fauna of Oregon and California, beyond those mountains.

Though there are some animals which traverse the chain of the Rocky mountains, and are found in the prairies of the Missouri as well as on the banks of the Columbia, as, for

* The types which are peculiar to temperate America, and are not found in Europe, are the opossum, several genera of Insectivora, among them the shrew-mole (*Scalops aquaticus*), and the star-nose mole (*Condylura crystata*), which replaces the Mygale of the Old World; several genera of rodents, especially the musk-rat. Among the types characteristic of America must also be reckoned the snapping-turtle among the tortoises; the Menobranchus and Menopoma among the Salamanders; the Garpike and Amia among the fishes; and finally among the Crustacea, the Limulus. Among the types which are wanting in temperate America, and which are found in Europe, may be cited the horse, the wild boar, and the true mouse. All the species of domestic mice which live in America have been brought from the Old World.

example, the Rocky Mountain deer (*Antilope furcifer*), yet, if we regard the whole assemblage of animals, they are found to differ entirely.

The faunas or zoological provinces of the Old World are:—

1st. The fauna of Europe, which is very closely related to that of the United States proper.

2nd. The fauna of Siberia, separated from the fauna of Europe by the Ural Mountains.

3rd. The fauna of the great Asiatic table-land, which, from what is as yet known of it, appears to be quite distinct.

4th. The fauna of China and Japan, which is analogous to that of Europe in the birds, and to that of the United States in the reptiles, as it is also in the flora.

Lastly, it is in the temperate zone of the northern hemisphere that we meet with the most striking examples of those local faunas which have been mentioned above. Such, for example, is the fauna of the Caspian Sea, of the Steppes of Tartary, and of the Western prairies.

The faunas of the southern temperate regions differ from those of the tropics as much as the northern temperate faunas do; and, like them also, may be distinguished into two provinces, the colder of which embraces Patagonia. But, besides differing from the tropical faunas, they are also quite dissimilar to each other on the different continents. Instead of that general resemblance, that family likeness which we have noticed between all the faunas of the temperate zone of the northern hemisphere, we find here the most complete contrasts. Each of the three continental peninsulas which jut out southerly into the ocean represents, in some sense, a separate world. The animals of South America, beyond the tropic of Capricorn, are, in all respects, different from those at the southern extremity of Africa. The hyænas, wild boars, and rhinoceroses of the Cape of Good Hope, have no analogues on the American continent; and the difference is equally great between the birds, reptiles and fishes, insects and mollusks.

New Holland, with its marsupial mammals, with which are associated insects and mollusks no less singular, furnishes a fauna still more peculiar, and which does not approach those of any of the adjacent countries.

### III. *Tropical Faunas.*

The tropical faunas are distinguished, on all the continents, by the immense variety of animals which they comprise, not less than by the brilliancy of their coverings. All the principal types of animals are represented, and all contain numerous genera and species. We need only refer to the tribe of humming-birds, which numbers not less than 300 species. But what is very important is, that here are concentrated the most perfect, and also the oddest types, of all the classes of the animal kingdom. The tropical region is the only one occupied by the Quadrumana, the herbivorous bats, the great pachydermata, such as the elephant, the hippopotamus, and the tapir, and the whole family of Edentata. Here, also, are found the largest of the cat tribe, the lion and tiger. Among the Birds we may mention the parrots and toucans, as essentially tropical; among the Reptiles, the largest crocodiles and gigantic tortoises; and, finally, among the articulated animals an immense variety of the most beautiful insects. The marine animals, as a whole, are equally superior to those of other regions; and the Polyps there display an activity of which the other zones present no example. Whole groups of islands are covered with coral reefs formed by those little animals.

The variety of the tropical fauna is further enriched by the circumstance that each continent furnishes new and peculiar forms. Sometimes whole types are limited to one continent, as the sloth, the toucans, and the humming-birds to America, the giraffe and hippopotamus to Africa; and, again, animals of the same group have different characteristics, according as they are found on different continents. Thus, the monkeys of America have flat and widely separated nostrils, thirty-six teeth, and generally a long, prehensile tail. The monkeys of the Old World, on the contrary, have nostrils close together, only thirty-two teeth, and not one of them has a prehensile tail.

But these differences, however important they may appear at first glance, are subordinate to more important characters, which establish a certain general affinity between all the faunas of the tropics. Such, for example, is the fact that the quadrumana are limited, on all the continents, to the warmest regions, and never, or but rarely, penetrate into the temperate zone. This distribution is a natural consequence of the distribution of the palms; for as these trees, which constitute the ruling feature of the flora of the tropics, furnish to a great extent, the food of the monkeys on the two continents, we have only to trace the limits of the extent of the palms to have a pretty accurate indication of the tropical faunas on all three continents.

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Several well-marked faunas may be distinguished in the tropical part of the American continent, namely :—

1. The fauna of Brazil, characterized by its gigantic reptiles, its monkeys, its edentata, its tapir, its humming-birds, and its astonishing variety of insects.

2. The fauna of the western slope of the Andes, comprising Chili and Peru ; and distinguished by its llamas, vicunas, and birds, which differ from those of the basin of the Amazon, as also do the insects and mollusks.

3. The fauna of the Antilles and the Gulf of Mexico. This is especially characterized by its marine animals, among which the manatée is particularly remarkable ; an infinite variety of singular fishes ; also Mollusks, and Radiata of peculiar species.

The limits of the fauna of Central America cannot yet be well defined, from want of sufficient knowledge of the animals which inhabit those regions.

The tropical zone of Africa is distinguished by a striking uniformity in the distribution of the animals, which corresponds to the uniformity of the structure and contour of that continent. Its most characteristic species are spread over the whole extent of the tropics: thus, the giraffe is met with from Upper Egypt to the Cape of Good Hope ; the hippopotamus is found at the same time in the Nile, the Niger, and Orange River. This wide range is the more significant as it also relates to herbivorous animals, and thus supposes conditions of vegetation very similar, over wide countries. Some forms are, nevertheless, circumscribed within narrow districts ; and there are marked differences between the animals of the eastern and western shores. Among the remarkable species of the African torrid regions are the baboons, the African elephant, the crocodile of the Nile, a vast number of antelopes, and especially two species of Ourang-outang, the chimpanzée, and the engeena, a large and remarkable animal, recently described by Drs. Savage and Wyman. The fishes of the Nile have a tropical character, as well as the animals of Arabia, which are more allied to those of Africa than to those of Asia.

The tropical fauna of Asia, comprising the two peninsulas of India and the isles of Sunda, is not less marked. It is the country of the gibbons, the red ourang, the royal tiger, the gavial, and a multitude of peculiar birds. Here, also, are found those curious spiny fishes, whose intricate gills suggested the name Labyrinthici, by which they are known.

Fishes with tufted gills are more numerous here than in other seas. The insects and mollusks are no less strongly characterized. Among others is the nautilus, the only living representative of the great family of large chambered-shells, which prevailed so extensively over other types in former geological ages.

The large island of Madagascar has its peculiar fauna, characterized by its makis and its curious rodents. Polynesia, exclusive of New Holland, furnishes a number of very curious animals, which are not found on the Asiatic continent: such are the herbivorous bats and the flying Maki.

### CONCLUSIONS.

From the survey we have thus made of the distribution of the animal kingdom, it follows—

1st. Each grand division of the globe has animals which are either wholly or for the most part peculiar to it. These groups of animals constitute the faunas of different regions.

2nd. The diversity of faunas is not in proportion to the distance which separates them. Very similar faunas are found at great distances apart; as, for example, the fauna of Europe and that of the United States, which yet are separated by a wide ocean. Others, on the contrary, differ considerably, though at comparatively short distances, as the fauna of the East Indies and the Sunda Islands, and that of New Holland, or the fauna of Labrador and that of New England.

3rd. There is a direct relation between the richness of a fauna and the climate. The tropical faunas contain a much larger number of more perfect animals than those of the temperate and polar regions.

4th. There is a no less striking relation between the fauna and flora, the limit of the former being oftentimes determined, so far as terrestrial animals are concerned, by the extent of the latter.

Animals are endowed with instincts and facilities corresponding to the physical character of the countries they inhabit, and which would be of no service to them under other circumstances. The monkey, which is a frugivorous animal, is organized for living on the trees from which he obtains his food. The reindeer, on the contrary, whose food consists of lichens, lives in cold regions. The latter would be quite out of place in the torrid zone, and the monkey would perish with hunger in the polar regions. Animals which store up provisions are all peculiar to temperate or cold climates. Their instincts would be uncalled for in tropical regions, where the vegetation presents the herbivora with an abundant supply of food at all times.

However intimately allied the climate of a country may be to the peculiar character of its fauna, we are not to conclude that the one is the consequence of the other. The differences which are observed between the animals of different faunas are no more to be ascribed to the influences of climate than their organization is to the influence of the physical forces of nature. If it were so, we should necessarily find all animals precisely similar when placed under the same circumstances. We shall find, by the study of the different groups in detail, that certain species, though very nearly alike, are nevertheless distinct in two different faunas. Between the animals of the temperate zone of Europe, and those of the United States, there is similarity, but not identity; and the particulars in which they differ, though apparently trifling, are yet perfectly constant.

Neither the distribution of animals, therefore, any more than their organization, can be the effect of external influences. We must, on the contrary, see in it the realization of a plan wisely designed, the work of a Supreme Intelligence, who created, at the beginning, each species of animal at the place, and for the place, which it inhabits. To each species has been assigned a limit, which it has no disposition to overpass so long as it remains in a wild state. Only those animals which have been subjected to the yoke of man, or whose subsistence is dependent on man's social habits, are exceptions to this rule.

As the human race has extended over the surface of the earth, man has more or less modified the animal population of different regions, either by exterminating certain species, or by introducing others with which he desires to be more intimately associated,—the domestic animals. Thus, the dog is found wherever we know of the presence of man; the horse, originally from Asia, was introduced into America by the Spaniards, where it has thrived so well that it is found wild, in innumerable herds, over the Pampas of South America and the prairies of the West. In like manner the domestic ox became wild in South America. Many less welcome animals have followed man in his peregrinations; as, for example, the rat and the mouse, as well as a multitude of insects, such as the house-fly, the cockroach, and others which are attached to certain species of plants, as the white butterfly, the Hessian-fly, &c. The honey-bee has also been imported from Europe.

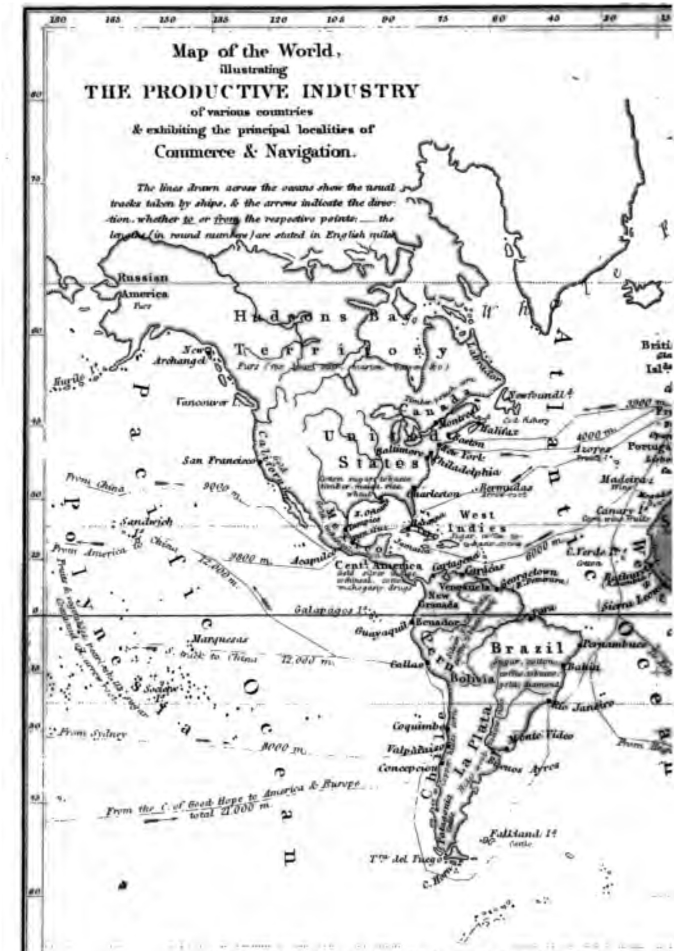
Among the species which have disappeared, under the influence of man, we may mention the Dodo, a peculiar species of bird which once inhabited the Mauritius, some remains of which are preserved in the British and Ashmolean Museums; a large cetacean of the north (*Rytina Stelleri*), which formerly inhabited the coasts of Behring's Straits, and which has not been seen since 1768. According to all appearances, we must also reckon among these the great stag, the skeleton and horns of which have been found buried in the peat-bogs of Ireland. There are also many species of animals whose numbers are daily diminishing, and whose extinction may be foreseen, as the Canada deer (*Wapiti*), the Ibex of the Alps, the Lämmergeyer, the bison, the beaver, the wild turkey, &c.

Other causes may also contribute towards dispersing animals beyond their natural limits. Thus, the sea-weeds are carried about by marine currents, and are frequently met with far from shore, thronged with little crustaceans, which are in this manner transported to great distances from the place of their birth. The drift-wood which the Gulf stream floats from the Gulf of Mexico even to the western shores of Europe, is frequently perforated by the larvæ of insects, and may probably serve as depositories for the eggs of fishes, crustacea, and mollusks. It is possible also that aquatic birds may contribute in some measure to the diffusion of some species of fishes and mollusks, either by the eggs becoming attached to their feet, or by means of those which they evacuate undigested, after having transported them to considerable distances. Still, all these circumstances exercise but a very feeble influence upon the distribution of species in general, and each country, none the less, preserves its peculiar physiognomy, so far as its animals are concerned.

The laws of distribution are not limited to the actual creation only; they have also ruled the creations of former geological epochs, and the fossil species have lived and died, most of them, in the spot where their remains are found.

Even man, although a cosmopolite, is subject, in a certain sense, to this law of limitation. While he is everywhere the one identical species, yet several races, marked by certain peculiarities of features, are recognized, such as the Caucasian, Mongolian, and African races. And it is not a little remarkable, that the abiding places of these several races correspond very nearly with some of the great zoological regions. Thus we have a northern race, comprising the Samoiedes in Asia, the Laplanders in Europe, and the Esquimaux in America, corresponding to the arctic fauna, and, like it, identical on the three continents, having for its southern limit the region of trees. In Africa, we have the Hottentot and Negro races, in the south and central portions respectively, while the people of northern Africa are allied to their neighbours in Europe, just as we have seen to be the case with the zoological fauna in general. The inhabitants of New Holland, like its animals, are the most grotesque and uncouth of all races.

The same arrangement holds good elsewhere, though not always in so remarkable a degree. In America, especially, while the aboriginal race is as well distinguished from other races as is its flora, the minor divisions are not so decided. Indeed, the facilities, or sometimes we might rather say necessities, arising from the varied supplies of animal and vegetable food in the several regions, might be expected to involve, with his corresponding customs and modes of life, a difference in the physical constitution of man, which would contribute to augment any primeval differences. It could not, indeed, be expected that a people constantly subjected to cold, like the people of the North, and living almost exclusively on fish, which they cannot obtain without great toil and peril, should present the same characteristics, either bodily or mental, as those who idly regale on the spontaneous bounties of tropical vegetation.



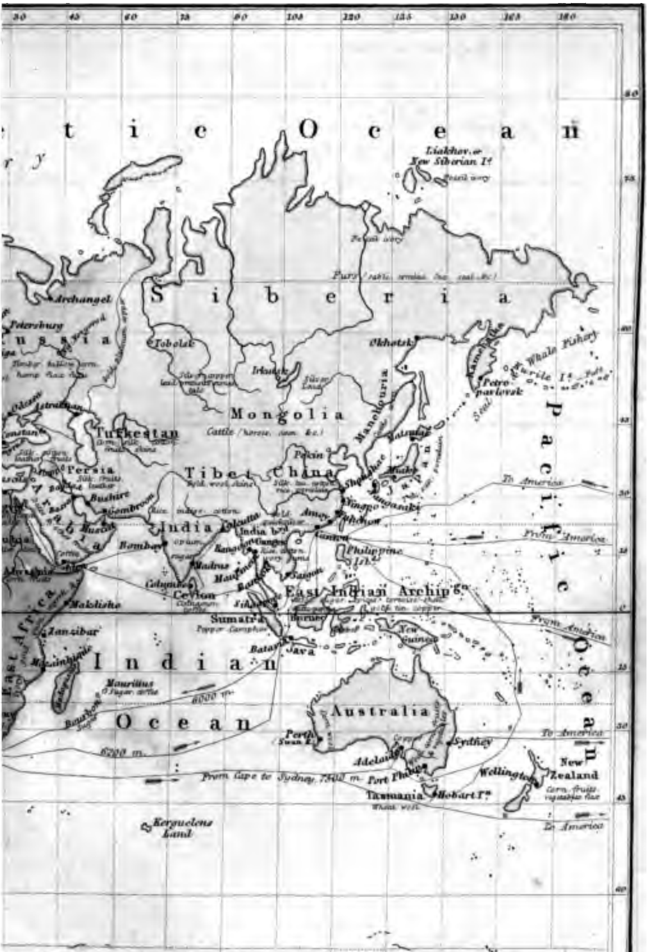
# Map of the World,
illustrating
# THE PRODUCTIVE INDUSTRY
of various countries
& exhibiting the principal localities of
# Commerce & Navigation.

*The lines drawn across the oceans show the usual tracks taken by ships, & the arrows indicate the direction, whether to or from the respective points: — the lengths (in round numbers) are stated in English miles.*

*Statistical Table of the principal Countries: the figures in the 1st column expres*

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Abyssinia* | 300.000 | 4.500.000 | 15 | *Canada* | 350.000 | 1.170.000 | 4 | *Germany* |
| *Austrian Empire* | 257.558 | 34.800.000 | 130 | *Cape Colony* | 178.000 | 200.000 | 1 | *Greece* |
| *Barbary (Morocco &c* | 650.000 | 10.000.000 | 15 | *Central America* | 186.000 | 1.900.000 | 9 | *Holland* |
| *Belgium* | 11.372 | 4.330.000 | 382 | *Chile* | 170.000 | 602.000 | 4 | *India* |
| *Bolivia* | 350.000 | 1.000.000 | 3 | *China* | 1.300.000 | 360.000.000 | 277 | *with* |
| *Brazil* | 2.500.000 | 6.000.000 | 2 | *Cuba* | 42.000 | 730.000 | 17 | *India beyon* |
| *British Isles:* | | | | *Denmark exclusive of Iceland & Faroe I's* | 21.856 | 2.132.000 | 97 | *Anam* |
| *England* | 50.387 | 15.000.000 | 298 | | | | | *Birmah* |
| *Wales* | 7.426 | 912.000 | 123 | Ecuador | 314.000 | 600.000 | 2 | Siam |
| *Scotland* | 30.016 | 2.620.000 | 87 | Egypt | 16.000 | 2.000.000 | 125 | Italy. inclu |
| *Ireland* | 31.874 | 8.175.000 | 256 | France | 203.736 | 35.400.000 | 173 | & |

Lon



iles.— the 2nd the Population.— & the 3rd the number of Inhabitants to a square mile.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ,000 | 170 | *Jamaica* | 6400 | 377,400 | 59 | *Prussia* | 107,894 | 16,113,000 | 150 |
| ,700 | 42 | *Japan* | 260,000 | 50,000,000 | 192 | *Russia (European)* | 2,000,000 | 54,000,000 | 27 |
| ,000 | 230 | *Java* | 50,000 | 8,000,000 | 160 | *Spain* | 182,770 | 12,387,000 | 67 |
| ,000 | 117 | *La Plata* | 726,000 | 3,000,000 | 1 | *Sumatra* | | 2,800,000 | |
| | | *Mexico* | 800,000 | 8,000,000 | 10 | *Sweden* | 170,240 | 3,139,000 | 18 |
| | | *New Granada* | 400,000 | 1,700,000 | 4 | *Switzerland* | 14,600 | 2,188,000 | 150 |
| ,000 | 31 | *Norway* | 122,460 | 1,168,000 | 9 | *Turkey (European)* | 210,000 | 12,000,000 | 57 |
| ,000 | 19 | *Persia* | 400,000 | 8,000,000 | 18 | *United States, ex-* | | | |
| ,000 | 30 | *Peru* | 465,000 | 1,350,000 | 3 | *clusive of Oregon* | 1,585,618 | 17,100,000 | 11 |
| ,000 | 201 | *Philippine Is* | | 2,500,000 | | *& California* | | | |
| | | *Portugal* | 35,356 | 3,400,000 | 92 | *Venezuela* | 405,000 | 1,050,000 | |

40 60 75 90 105 120 135 150 165

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# CHAPTER XVIII.

## MAP VII.

### PRODUCTIVE INDUSTRY AND COMMERCE OF THE DIFFERENT COUNTRIES OF THE GLOBE.

### *Origin and Influence of Commerce.*

THE origin of commerce is coeval with the first dawn of civilization; the moment that individuals ceased to supply themselves directly with the various articles and accommodations they made use of, that moment must a commercial intercourse have begun to grow up amongst them. For it is only by exchanging that portion of the produce raised by ourselves which exceeds our own consumption, for portions of the surplus produce raised by others, that the division of employments can be introduced, or that different individuals can apply themselves in preference to different pursuits.

Not only, however, does commerce enable the inhabitants of the same village or parish to combine their separate efforts to accomplish some common object, but it also enables those of different provinces and kingdoms to apply themselves in an especial manner to those callings for the successful prosecution of which the district or country which they occupy gives them some peculiar advantage. This territorial division of labour has contributed more, perhaps, than anything else to increase the wealth and accelerate the civilization of mankind. Were it not for it, we should be destitute of a vast number of the necessaries, comforts, and enjoyments which we now possess; while the price of the few that would remain would, in most instances, be very greatly increased. But whatever advantages may be derived,—and it is hardly possible to exaggerate either their magnitude or importance,—from availing ourselves of the peculiar capacities of production enjoyed by others, are wholly to be ascribed to commerce as their real source of origin. As these advantages have been pointed out by some of the best of our writers, we shall here make the following extracts from their works.

"With the benefit of commerce, or a ready exchange of commodities, every individual is enabled to avail himself to the utmost of the peculiar advantage of his place; to work on the peculiar materials with which nature has furnished him; to humour his genius or disposition, and betake himself to the task in which he is peculiarly qualified to succeed. The inhabitant of the mountain may betake himself to the culture of his woods and the manufacture of his timber; the owner of pasture lands may betake himself to the care of his herds; the owner of the clay-pit to the manufacture of his pottery; and the husbandman to the culture of his fields, or the rearing of his cattle. And any one commodity, however it may form but a small part in the accommodations of human life, may, under the facility of commerce, find a market in which it may be exchanged for what will procure any other part, or the whole; so that the owner of the clay-pit, or the industrious potter, without producing any one article immediately fit to supply his own necessities, may obtain possession of all that he wants. And commerce, in which it appears that commodities are merely exchanged, and nothing produced, is nevertheless, in its effects, very productive, because it ministers a facility and an encouragement to every artist in multiplying the productions of his own art; thus adding greatly to the mass of wealth in the world, in being the occasion that much is produced."*

"The commerce of one country with another is, in fact, merely an extension of that division of labour by which so many benefits are conferred upon the human race. As the same country is rendered the richer by the trade of one province with another; as its labour becomes thus infinitely more divided and more productive than it could otherwise have been; and as the mutual supply to each other of all the accommodations which one province has, and another wants, multiplies the accommodations of the whole, and the country becomes thus in a wonderful degree more opulent and happy; the same beautiful train of consequences is observable in the world at large,—that great empire, of which the different kingdoms and tribes of men may be regarded as the provinces. In this magnificent empire, too, one province is favourable to the production of one species of accommodation, and another province to another; by their mutual intercourse they are enabled to sort and distribute their labour, as most peculiarly suits the genius of each particular spot. The labour of the human race thus becomes much more productive, and every species of accommodation is afforded in much greater abundance. The same number of labourers whose efforts might have been expended in producing a very insignificant quantity of home-made luxuries, may thus in Great Britain produce a quantity of articles for exportation, accommodated to the wants of other places, and peculiarly suited to the genius of Britain, to furnish which will purchase for her an accumulation of the luxuries of every quarter of the globe. There is not a greater proportion of her population employed in administering to her luxuries, in consequence of her commerce, there is probably a good deal less, but their labour is infinitely more productive; the portion of commodities which the people of Great Britain acquire by means of the same labour is vastly greater." †

Mr. Hume has beautifully illustrated the powerful and salutary influence of that spirit of industry and enterprize resulting from the eager prosecution of commerce and the arts.

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* Ferguson's 'Principles of Moral Science.'

† Mills's 'Commerce Defended.'

"Men," says he, "are then kept in perpetual occupation, and enjoy as their reward the occupation itself, as well as those pleasures which are the fruits of their labour. The mind acquires new vigour; enlarges its powers and faculties; and, by an assiduity in honest industry, both satisfies its natural appetites and prevents the growth of unnatural ones, which commonly spring up when nourished with ease and idleness. Banish those arts from society, you deprive men both of action and of pleasure; and leaving nothing but indolence in their place, you even destroy the relish of indolence, which never is agreeable but when it succeeds to labour, and recruits the spirits, exhausted by too much application and fatigue.

"Another advantage of industry and of refinements in the mechanical arts is, that they commonly produce some refinements in the liberal, nor can the one be carried to perfection without being accompanied in some degree with the other. The same age which produces great philosophers and politicians, renowned generals and poets, usually abounds with skilful weavers and ship-carpenters. We cannot reasonably expect that a piece of woollen cloth will be wrought to perfection in a nation which is ignorant of astronomy, or where ethics are neglected. The spirit of the age affects all the arts, and the minds of men, being once roused from their lethargy, and put into fermentation, turn themselves on all sides, and carry improvements into every art and science. Profound ignorance is totally banished, and men enjoy the privilege of rational creatures, to think as well as to act, to cultivate the pleasures of the mind as well as those of the body.

"The more these refined arts advance, the more sociable do men become; nor is it possible that when enriched with science, and possessed of a fund of conversation, they should be contented to remain in solitude, or live with their fellow-citizens in that distant manner which is peculiar to ignorant and barbarous nations. They flock into cities, love to receive and communicate knowledge, to show their wit or their breeding, their taste in conversation or living, in clothes or furniture. Curiosity allures the wise, vanity the foolish, and pleasure both. Particular clubs and societies are everywhere formed. both sexes meet in an easy and sociable manner, and the tempers of men, as well as their behaviour, refine apace. So that beside the improvements they receive from knowledge and the liberal arts, it is impossible but they must feel an increase of humanity from the very habit of conversing together, and contributing to each others pleasure and entertainment. Thus industry, knowledge, and humanity, are linked together by an indissoluble chain, and are found from experience, as well as reason, to be peculiar to the more polished, and what are commonly denominated the more luxurious, ages." *

"There is one opinion that universally prevailed among the ancients, which conveys a more striking idea of the small progress they had made in the knowledge of the habitable globe than can be derived from any detail of their discoveries. They supposed the earth to be divided into five regions, which they distinguished by the name of zones. Two

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* Essay on 'Refinement in the Arts.'

of these, which were nearest to the poles, they termed frigid zones, and believed that the extreme cold which reigned perpetually there rendered them uninhabitable. Another, seated under the line, and extending on either side towards the tropics, they called the torrid zone, and imagined it to be so burnt up with unremitting heat as to be equally destitute of inhabitants. On the two other zones, which occupied the remainder of the earth, they bestowed the appellation of temperate, and taught that these, being the only regions in which life could subsist, were allotted to man for his habitation. This wild opinion was not a conceit of the uninformed vulgar, or a fanciful fiction of the poets, but a system adopted by the most enlightened philosophers, the most accurate historians and geographers in Greece and Rome. According to this theory, a vast portion of the habitable earth was pronounced to be unfit for sustaining the human species. Those fertile and populous regions within the torrid zone which are now known not only to yield their own inhabitants the necessaries and comforts of life with most luxuriant profusion, but to communicate their superfluous stores to the rest of the world, were supposed to be the mansion of perpetual sterility and desolation. As all the parts of the globe with which the ancients were acquainted lay within the northern temperate zone, their opinion that the other temperate zone was filled with inhabitants was founded on reasoning and conjecture, not on discovery. They even believed that, by the intolerable heat of the torrid zone, such an insuperable barrier was placed between the two temperate regions of the earth as would prevent for ever any intercourse between their respective inhabitants. Thus this extravagant theory not only proves that the ancients were unacquainted with the true state of the globe, but it tended to render their ignorance perpetual, by representing all attempts towards opening a communication with the remote regions of the earth as utterly impracticable." *

*Industry.*—As the productive industry of a country depends chiefly upon physical causes, and since Europe possesses these in a degree better suited to rouse and stimulate human energy than any other of the great continents, its inhabitants are therefore more variously and extensively employed; whether pastoral, agricultural, manufacturing, or commercial, their industry is unrivalled. Not only does Europe manufacture its own raw produce, but also that of almost every other region of the globe; it sends out the most useful fabrics in such profusion, and at so cheap a rate, as to place them within the reach of almost every class of society; the young nations that have issued from its own bosom are thus clothed with cheaper and better articles than they could possibly manufacture from their own raw material.

The breeding of cattle and sheep forms an important branch of rural industry in the British isles; of cattle alone in the Netherlands and Russia; and of sheep and goats in the mountainous districts of Europe.

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* Robertson's 'History of America.'

Agriculture is carried to great perfection in the east of England, and in Scotland, the Netherlands, Germany, and the northern parts of France and Italy. Though not so advanced in Russia, Hungary, and Poland, yet, from the extreme richness of the soil, these countries are the granaries of Europe. Husbandry is pursued with great vigour in Great Britain, the Netherlands, Switzerland, Germany, the northern parts of Italy, and in Denmark and Sweden.

The cultivation of the finer fruits belongs to the temperate districts of France and Germany, but only in the southern parts of Europe can they be reared to perfection. The wine-grape is plentiful in France, Spain, Portugal, Italy, southern Germany, Hungary, and the Turkish empire. The finest wines are produced in the neighbourhood of Tokay, in Hungary, upon the chalk hills of Champagne, the gold hills of Burgundy, the banks of the Rhine and Rhone, and in Spain and the Two Sicilies.

The cultivation of the olive, and the rearing of silkworms, are extensively carried on in Italy, the former in the Neapolitan territory, the latter in Lombardy.

Fishing affords occupation to numbers of the inhabitants of the coast nations, who take herrings, tunnies, anchovies, mackerel, and various species of fish, from the surrounding seas. Mining is conducted with great skill and perseverance in England, Sweden, Germany, and Hungary.

Manufactures have risen to an unparalleled height in Great Britain, the Netherlands, France, Germany, and Switzerland. The best woollen and cotton fabrics are made in England, France, and Saxony; linen in Ireland and Germany; lace in the Netherlands, and silks in France; leather in Turkey and Russia; china in Germany; earthenware and china in England and France; glass in Bohemia and England; millinery in France; and jewellery work in France, Germany, England, and Switzerland.

*Commerce.*—At no period of the world's history has commerce been on so extensive a scale as at this moment. European vessels are now found in every port, from the neighbourhood of the icy poles to the scorching climes of the torrid zone, whilst internal communication is carried on by means of well-constructed high-roads, canals, and railways, with a vigour hitherto unknown.

The nations most distinguished for commerce are Great Britain, France, Holland, Denmark, Sweden, Russia, and the United States. No nation, however, can in this respect be compared with Great Britain, whose insular position and internal resources have enabled her to outrival all continental nations: her fleets are in every sea, and her colonies in every region of the earth. This extensive commerce has obtained for her an unparalleled degree of maritime greatness; and the courage and daring with which British seamen have at all times maintained their superiority, cause the British flag to be respected by all nations, and to float triumphant upon every sea.

### *Trade Routes.*

Map 7 exhibits the tracks usually taken by ships across the Pacific, Indian, and Atlantic Oceans, in their voyages *to* and *from* the respective localities of commerce, and also the "overland route," as it is called, to India. The causes which combine to produce a difference in the direction of *outward* and *homeward* tracks are the influences of particular winds and currents. It is the business of the skilful seaman of the present day not only to know where prevailing winds and currents are to be met with, but also to turn them to the best advantage in prosecuting his voyage. On this subject Captain Basil Hall remarks,—"It is one of the chief points of a seaman's duty to know where to find a fair wind, and where to fall in with a favourable current. If we take a globe and trace on it the shortest route by sea to India, and then fancy that such must be the best course to follow, we shall be very much mistaken. And yet this is very much what our ancestors did, till time, and repeated trials, nnd multitudinous failures, gradually taught them where to seek for winds, and how to profit by them when found. According to this 'rule-of-thumb' sailing, a ship had only to steer from England to Madeira, pass the Canaries and Cape de Verdes, and then to make a direct course to the Cape, and thence to India. On trial, however, this experiment always failed, for on getting near the equator a series of calms and squalls put a stop to this rectilinear scheme, and the mariners of old were then forced to toil along the coast of Africa, or were driven towards that of the Brazils, and very often they came back in utter hopelessness."

Directions for the navigation of the different seas and oceans are now given in such works as Norie's "Sailing Directions," Horsburgh's "East Indian Sailing Directory," &c., &c.

It may be necessary here to remark what is meant by the *direction* of the winds, waves, and currents, &c.

The direction of the wind is named according to the point *from* which it blows.

The direction of the waves, swell, or sea, is named according to the point *from* which they proceed.

The direction of the current is named according to the point *to* which it is running.

The course steered by a ship signifies her course by compass or magnetic bearing.

All the bearings are by *compass*.

## CHIEF PRODUCTIONS OF THE EARTH AND THE COUNTRIES WHERE THEY ARE PRODUCED.

*Almonds.*—Syria, Tripoli, Barbary, Spain, Portugal.
*Aloes.*—Socotra, Arabia, Barbadoes, South Africa.
*Allspice.*—Jamaica.
*Amethyst.*—Brazil, Siberia, Ceylon, Turkestan.
*Arrow-root.*—South America, East and West Indies, South Sea Islands.
*Barley.*—Between latitude 69½° and 45° Eastern Hemisphere, British America, and Australia.
*Bread-fruit.*—Polynesia, East Indies.
*Cocoa.*—West Indies, South America.
*Cassia.*—East and West Indies.
*Chestnuts.*—Spain, Italy, Corsica, Turkey.
*Cinnamon.*—Ceylon, Cochin China.
*Citron.*—Madeira, Polynesia.
*Cloves.*—Molucca Islands.
*Coal.*—Britain, Belgium, United States, Australia, Hindostan, China.
*Cochineal.*—Mexico, West India Islands.
*Cocoa-nuts.*—Ceylon, Maldive Islands, Siam, Brazil, Bengal, Polynesia, Africa.
*Coffee.*—Arabia, Java, West Indies, Brazil, Mauritius.
*Copper.*—Britain, Sweden, Siberia, Persia, Japan, Chili.
*Cork.*—France, Spain, Portugal, Italy, Barbary.
*Cotton.*—Grows naturally in Asia, Africa, and America; it is cultivated in the United States, and some parts of Europe.
*Currants.*—Ionian Islands and Greece.
*Dates.*—Egypt, Barbary, Arabia, Persia.
*Diamond.*—Brazil, Borneo, India, Ural Mountains.
*Ebony.*—Mauritius, Madagascar, Ceylon.
*Emerald.*—Peru.
*Figs.*—Turkey, Greece, France, Spain, Italy, North Africa.
*Flax.*—Russia, Egypt, Ireland, Netherlands, New South Wales.
*Furs.*—North America, Russia, United States.
*Gamboge.*—Siam, Cambodia.
*Gold.*—Australia, California, Mexico, South America, Russia, India, Africa, Hungary, Saxony.
*Hemp.*—Russia, Italy, Philippine Islands, Brazil, Britain, Egypt, North America.
*Indigo.*—East and West Indies, Guinea.
*Ipecacuanha.*—Brazil, South America.
*Iron.*—Most countries, more particularly Britain and Sweden.
*Ivory.*—Africa, East Indies.
*Lead.*—Britain, United States, Germany, Spain, Siberia, Armenia.
*Lemon.*—Syria, Persia, Greece, Italy, Spain, Portugal, Azores.
*Mace.*—East and West Indies.
*Mahogany.*—West Indies, Central America.
*Maize, or Indian corn.*—America, from Canada to La Plata, South Europe, Central Africa, Australia.
*Maple Sugar.*—Canada.
*Marble.*—Italy, Greece, Egypt, Siberia, Britain, France, Flanders.
*Melon.*—South Europe, South Asia, Polynesia.
*Mercury.*—Spain, Italy, Peru, China, Tibet.
*Millet.*—Germany, Poland, India, Africa.
*Molasses.*—West Indies, Mauritius.
*Morocco.*—Levant, Barbary, Spain, Flanders.
*Mulberry and Silk-worms.*—South Europe, South Asia.
*Nutmeg.*—Moluccas, Sumatra, Penang, Borneo.
*Oats.*—Chiefly grown in latitudes north of Paris, though cultivated in Bengal as low as the 25th degree.
*Olive.*—Syria, Greece, Africa, Spain, Italy, Brazil, the Ionian Islands.
*Opal.*—Hungary, East Indies.
*Oranges.*—The Azores, Spain, Portugal, China, Italy, Malta, Polynesia.
*Palm-oil.*—Western Africa, Fernando Po, Brazil, Hindoostan.
*Pepper.*—East and West India Islands, French Guiana.
*Pine-apple.*—Mexico, West Indies, Hindoostan, Polynesia.
*Plantain or Banana.*—Tropical America (especially in Mexico), Polynesia, East Indies.
*Platina.*—Spain, Asiatic Russia, South America.
*Pomegranate.*—Persia, South Europe, Tropical Asia, West Indies.
*Prunes.*—South France.
*Raisins.*—Smyrna, Valencia, Malaga, Italy.
*Rice.*—India, China, West Indies, United States, Italy, Africa.
*Ruby.*—Ava, South America, Siberia, Egypt, Ceylon, China.
*Rye.*—The Bread-corn of Germany and Russia.
*Sago.*—East Indies.
*Sapphire.*—Ava, Bohemia, Saxony, France.
*Silver.*—Mexico, Peru, Hungary, Saxony, Asiatic Russia.
*Sponge.*—Found upon the Rocks of the Mediterranean and Red Sea.
*Sugar-cane.*—Tropical America, East and West Indies, Sicily, Canary Islands, Polynesia, Africa, Brazil.
*Sugar from Beet-root.*—France, Belgium, Germany, Prussia, Russia.
*Tamarinds.*—East and West Indies, Arabia, Egypt, Cuba, Brazil.
*Tapioca.*—South America, West Indies.

*Tea.*—China, Japan, Assam.

*Tin.*—Cornwall, Devon, Galicia, Erz-gebirge Mountains in Saxony, Bohemia, Malay, China, Island of Banca in East Indies, Celebes.

*Tobacco.*—Tropical America, United States, Turkey, Asia, Prussia France, Australia.

*Topaz.*—South America, India, Egypt, Siberia, Mexico.

*Turquoise.*—Nishapore, in Persia.

*Vine.*—South Europe, Canary Islands, Africa, North America to latitude 40° Brazil.

*Wheat.*—We are in total ignorance where this important grain was first cultivated; some suppose in Northern Africa. It is raised in almost every part of the temperate zones. Little is grown beyond latitude 50° in Europe, but on the Alps it ripens at a height of 8,500 feet above the level of the sea.

*Wines.*—*Port*—Province of Upper Douro, in Portugal. *Sherry*—Xeres, near Cadiz, in Spain. *Claret*—Bordeaux, in France. *Champagne*—From a province in France of the same name. *Burgundy*—Ditto. *Madeira*—From the Madeira Islands. *Malmsey*—Ditto. *Teneriffe*—From the Island of Teneriffe. *Marsala*—Sicily. *Cape*—From South Africa.

*Yam.*—Africa, South America, Polynesia, Australia.

## ARTICLES IMPORTED INTO THE BRITISH ISLANDS FROM OTHER COUNTRIES.

### EUROPE.

*Russia.*—Timber, deals, tallow, corn, hemp, flax, furs, linseed, hides, leather, pitch, tar, wax, feathers, pearl ashes.

*Sweden and Norway.*—Timber, deals, iron, pitch, tar, turpentine, resin, oak-bark, juniper-berries, and fish.

*Germany.*—Wheat in large quantities from Dantzic; hemp, flax, wool, bark, amber, Rhenish wines, hops, toys, &c.

*Denmark.*—Hogs, rape-seed, fish, and feathers.

*Holland and Belgium.*—Butter, cheese, spirits, flower-roots, madder, hops, lace and linen, clocks, toys, &c.

*France.*—Wines, brandy, fruits, silks and gloves, perfumery, trinkets, and fancy articles.

*Spain.*—Wine, fruits, olive oil, cork, wool.

*Portugal.*—Wine, fruits, cork.

*Italy.*—Raw and manufactured silks, fruits, olive oil, straw plait, cheese, maccaroni, vermicelli, sulphur, pumice-stone, marble.

*Greece.*—Raw silk, dried fruits.

*Turkey.*—Leather, raw silks, figs.

### ASIA.

*Hindoostan.*—Silk, sugar, coffee, pepper, indigo, rice, lac dye, saltpetre, precious stones.

*Birman Empire.*—Teak, timber, rice, indigo, gums, drugs, palm sugar, cotton goods, silk, varnish.

*China.*—Tea, silk, cotton goods, porcelain, lacquered ware, gums paper, drugs.

*Japan.*—Silk and cotton goods, drugs, spices, varnish, porcelain, rice, cedar.

*Persia.*—Silks, carpets, cotton goods, shawls, stuffs, sugar, rice, dried fruits, leather, drugs, tobacco.

*Arabia.*—Coffee, aloes, gums, myrrh, frankincense, perfumes, drugs.

*Turkey in Asia.*—Coffee, carpets, silks, fruits, drugs, opium.

*Siberia.* Furs and minerals.

*Kamtschatka.*—Furs and dried fish.

*Asiatic Islands.*—Cinnamon, cloves, nutmegs, pepper, ginger, sago, camphor.

### AFRICA.

*Mauritius.*—Palm oil, teak timber, aloes, dye-woods, ostrich feathers, ivory, gold, sugar.

*Morocco.*—Leather, goat-skins, gums, fruits.

*Algiers and Tripoli.*—Ostrich feathers, dates, wax, wool.

*Egypt.*—Cotton, indigo, drugs, fruits, rice.

*Madeira Islands.*—Wine, fruits.

*Canary Islands.*—Wine, fruits, silk, barilla.

### NORTH AMERICA.

*Canada.*—Timber, corn, pot and pearl-ashes, furs.

*Newfoundland.*—Cod-fish.

*Nova Scotia.*—Timber, dried fish, plaster of Paris.

*Hudson's Bay, and Columbia River.*—Furs.

*United States*:—

*Northern States.*—Timber, fish, beef, pork, pot and pearl-ashes.

*Middle States.*—Wheat, flour; and, from Maryland, tobacco.

*Southern States.*—Cotton, tobacco, rice.

*Mexico.*—Silver and gold.

### SOUTH AMERICA.

*Caraccas.*—Cocoa, coffee, indigo, tobacco.

*Guiana.*—Sugar, rum, cotton, coffee, tobacco, indigo, cayenne pepper.

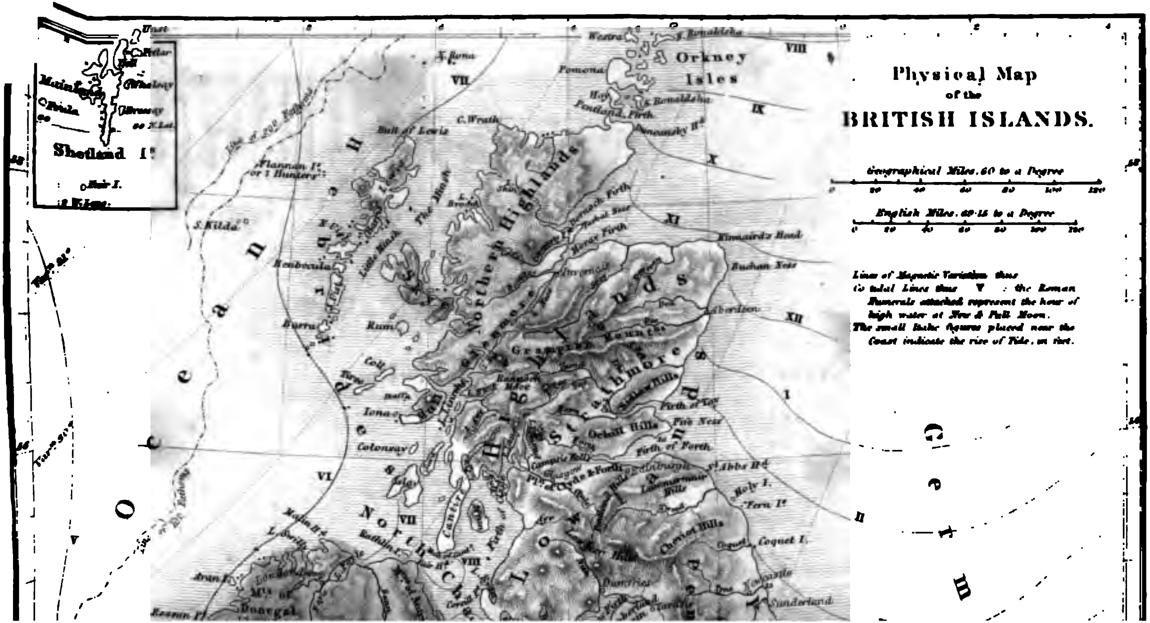
*Brazil.*—Cotton, sugar, coffee, tobacco, dye-woods; drugs from the northern provinces; gold and diamonds from the middle; and wheat, hides, and tallow, from the southern.

*Buenos Ayres.*—Gold and silver, hides, beef, and tallow.

*Peru.*—Silver and gold.

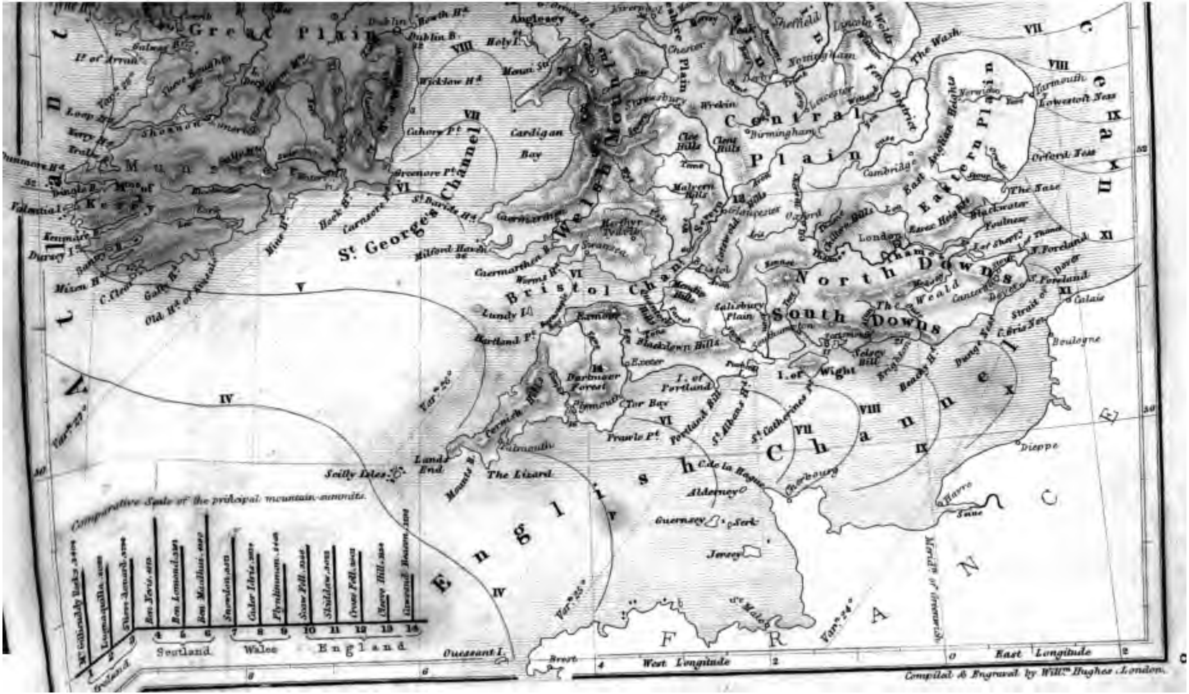
*Chili.*—Silver, gold, and copper, from the northern provinces; wheat, and hemp, from the southern

*West Indies.*—Sugar, coffee, rum, molasses, cotton, pimento, ginger, logwood, mahogany, cocoa, cochineal, cigars.



Physical Map of the BRITISH ISLANDS.

Lines of Magnetic Variation thus
Co-tidal Lines thus V : the Roman Numerals attached represent the hour of high water at New & Full Moon.
The small Italic figures placed near the Coast indicate the rise of Tide, in feet.


Atlantic Ocean
German Ocean
Great Plain
Munster
Kerry
Dublin
Dublin B.
Howth Hd.
Anglesey
Holy I.
Wicklow Hd.
Carnsore Pt.
St. George's Channel
Cardigan Bay
Welsh Mountains
Milford Haven
St. Davids Hd.
Bristol Channel
Lundy I.
Hartland Pt.
Dartmoor Forest
Exmoor
Blackdown Hills
Cheshire Plain
Central Plain
Birmingham
Shrewsbury
Wrekin
Malvern Hills
Clee Hills
Cotswold Hills
Oxford
Chiltern Hills
London
Thames
Cambridge
Eastern Plain
East Anglian Heights
Fen District
The Wash
Norwich
Yarmouth
Lowestoft Ness
Orford Ness
The Naze
North Downs
South Downs
The Weald
Canterbury
N. Foreland
S. Foreland
Dover
Strait of Dover
Calais
Boulogne
Dieppe
Havre
Seine
Salisbury Plain
I. of Wight
Selsey Bill
Beachy Hd.
Dungeness
Exeter
Plymouth
Tor Bay
I. of Portland
Portland Bill
St. Albans Hd.
St. Catherines Pt.
Prawle Pt.
Falmouth
The Lizard
Lands End
Scilly Isles
Cornish Hills
English Channel
C. de la Hague
Cherbourg
Alderney
Guernsey
Sark
Jersey
St. Malo
Brest
Ouessant I.
France
Meridn. of Greenwich
West Longitude
East Longitude
Comparative Scale of the principal mountain-summits.
Mc. Gillicuddy Reeks
Lugnaquilla
Slieve Donard
Ben Nevis
Ben Lomond
Ben Macdhui
Snowdon
Cader Idris
Plynlimmon
Scaw Fell
Skiddaw
Cross Fell
Cleeve Hill
Ireland
Scotland
Wales
England
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Compiled & Engraved by Willm. Hughes London.

# CHAPTER XIX.

## MAP VIII.

### PHYSICAL FEATURES OF THE BRITISH ISLANDS.

THE British Islands comprehend Great Britain and Ireland, and the numerous islets and rocks off their shores. The whole group presents the appearance of having been separated at some remote period from the adjoining continent, and from one another, probably by oceanic or volcanic agency. This conclusion has been come to from the fact that the Dover cliffs correspond in geological formation with the opposite shores of France; and the abrupt coast of the north-east of Ireland is of a similar character to the opposite shores of Scotland.

The eastern and western shores of the British Islands present a striking contrast. On the east, the coast line is slightly indented, with but few harbours, and is for the most part flat, sandy, and shingly. The western shore is rock-bound, with bold headlands, abounding in harbours, and deeply indented with bays, which penetrate far into the land; this results from the whole western coast line being continually lashed by the heavy swells which roll in from the Atlantic.

On the southern coast there are several admirable ports and some considerable bays, though none of them, with the exception of the Cove of Cork, are on a very large scale.

Great Britain, the larger of the two principal islands, measures, from Lizard Point, near Falmouth, to Dunnet Head, in Caithness, a distance of about 600 miles. Its greatest breadth, from the Land's End, in Cornwall, to a point near Lowestoft, on the coast of Norfolk, is 367 miles; but the distance from sea to sea is considerably less in some places, being under 40 miles. The climate, though subject to sudden changes, is protected by the surrounding ocean from the extremes of cold, heat, and aridity to which the continental countries are subject.

England is the southern and larger portion, Scotland the northern and smaller part, of the island.

### I. *England and Wales.*

The figure of England, including Wales, is that of a triangle, the base being formed by a line drawn from the Land's End to the South Foreland; a line drawn thence to Berwick forms the eastern side, and the third side is formed by a line extending from Berwick to the Land's End. The superficial area has been variously estimated; but the authority most to be relied on reduces the area of England and Wales to 57,812 square miles.

Few countries exhibit a greater variety of surface than England, or have been more highly favoured by nature. "Although," says Dr. Aikin, "its features are moulded on a comparatively minute scale, they are marked with all the agreeable interchange which constitutes picturesque beauty. In some parts, plains clothed in the richest verdure, watered by copious streams, and pasturing innumerable cattle, extend as far as the eye can reach; in others, gently rising hills and bending vales, fertile in corn, waving with woods, and interspersed with flowery meadows, offer the most delightful landscapes of rural opulence and beauty. Some tracts furnish prospects of the more romantic and impressive kind: lofty mountains, craggy rocks, deep dells, narrow ravines, and tumbling torrents: nor is there wanting, as a contrast to those scenes in which every variety of nature is a different charm, the vicissitude of black barren moors and wide inanimated heaths."

Such is a vivid description of the general appearance of England, the more striking features of which are clearly delineated upon the map. But the beauty and fertility of the country are not the only things to excite admiration; the mildness of the climate, removed alike from the extremes of heat and cold; the multitude of rivers, their depth, and the facility they afford to internal navigation; the vast beds of coal and other valuable minerals hid under the surface; the abundance and excellence of the fish in the rivers and surrounding seas; the extent of sea-coast; the number, capaciousness, and safety of the ports and bays; and the favourable situation of the country for commerce, give England advantages that are not enjoyed in an equal degree by any other nation.

In the north-west the country is mountainous, the west and south hilly, the centre undulating, and the eastern coast low and flat. The midland and southern parts are the richest and most fertile; the western districts are best adapted for pasturage, and the eastern for tillage.

The British Isles afford a wide field for the study of hydrography, since they present the best developed river systems of any country on the surface of the globe; Mr. Augustus Petermann has laid down upwards of 1,500 rivers upon his Hydrographical Map, exhibiting the inland waters of the British Isles. Many of the English rivers, as the Thames, Medway, Humber, and Tyne, on the east side, and the Mersey and Severn on the west, are fine navigable streams. The Trent, Ouse, Tees, Wear, Avon, Derwent, and others, fertilize and enrich the districts through which they flow. There are a few lakes in Cumberland and Westmoreland, which are remarkable for their beauty and picturesque scenery. About a fourth part of the whole surface is occupied by well-wooded parks, connected with the residences of the nobility and gentry; the remaining portion presents evidences of long-continued cultivation.

Whilst there are few countries which present to the eye a more beautiful landscape, there is, perhaps, no portion of the earth's surface, of the same extent, which contains so many of those mineral substances that minister to the necessities and comforts of life; and it would appear from her valuable resources of coal, and of iron and other metals, her insular position, her temperate climate, her capability of supplying almost all the wants of man, as if God, in his providence, had pre-ordained that England should be the seat of an opulent and powerful people, and one of His chief instruments for the civilization and advancement of the human race.

*Wales* is remarkable for its bold mountain scenery. The loftiest mountains, as Snowdon, Cader Idris, Plynlimmon, &c., are in North Wales; and here the valleys, with the exception of that of Clwyd, are deep and narrow. The vale of Llangollen is celebrated for its great beauty. In South Wales the valleys are broad, more fertile, and contain a greater number of towns and villages; though not on so grand a scale as in North Wales, the scenery is equally romantic, and mingles a greater degree of softness and cultivation. The agricultural and mining products are also of much greater value. Wales is well watered by innumerable streams that force their way through deep rocky recesses, assuming in their descent every variety of waterfall, and roll into the valleys, where they unite and form rivers, which, at their confluence with the sea, form excellent harbours.

## II. *Scotland.*

The greatest length of Scotland, from the Mull of Galloway, its most southerly point, to Dunnet Head, its most northerly point, is about 280 miles. The breadth is extremely various; this arises from the country being so much penetrated by *firths*, or arms of the sea, so that no one place is more distant than 40 miles from shore to shore. The greatest breadth, which is between Buchan Ness, on the coast of Aberdeen, and Rowanmoan Point, on the west coast of Ross-shire, is about 146 miles. In one place it is only 32 miles from shore to shore, and in another only 24 miles.

The figure of the country is extremely irregular, and, as compared with England, its surface is, generally speaking, sterile, rugged, and mountainous. The whole country, in its general outline, consists of two great and perfectly distinct parts, the Highlands and the Lowlands. The former comprehends the whole of the west and centre of that portion of Scotland which lies to the north of the Firths of Forth and Clyde. The latter comprises the lowland lying to the south of this line, and the lowland extending along the west coast from the Firth of Forth to the Moray Firth.

The Highlands are occupied by a long chain of lofty, rugged mountains, generally called the Grampians, that bear from N.E. to S.W. From this elevated region numerous streams issue, which roll through the chasms of the mountains and lose themselves in beautiful romantic lakes, or join in forming rivers that wind through the Lowlands, enriching and fertilizing the country through which they flow, till they meet the ocean, and there expand into broad estuaries, that become the channels of extensive commerce. The natural features of Scotland are best described by one of its own bards, in calling it "the land of mountain and of flood." The Highlands, and many southern districts, are well adapted to the rearing of cattle, which are exported in large numbers to England.

The eastern Lowland contains arable land, chiefly the broad flat valleys along the firths; several of these are much famed for their fertility, and are in a high state of cultivation. There is, perhaps, no country where agriculture is better understood than in the Lowlands of Scotland.

The southern Lowland, which extends to the English border, contains several hill ranges and wide tracts of moor: a large part of it, however, is very fertile: its verdant plains, beautiful streams, and rich pasture lands, give it all the appearance of an English landscape.

The islands of Scotland are numerous, and lie principally on the north and west coast; the larger groups are the Orkney, Shetland, and Hebrides.

From the vast extent of surface occupied by rugged mountains, hill ranges, and morasses, the cultivated lands are still limited. The chief vegetable products are wheat, oats, and barley. The second of these forms the staple produce of Scotland, and is the food of the rural population. Barley is raised principally for the purpose of distillation. Fruits ripen in the open air as far north as Inverness, and forests of pine clothe the Highland valleys and mountains.

The great mineral products are coal, iron, lime, and building stone. The coal-fields extend in a diagonal line of 100 miles along the Firths of Forth and Clyde, and are immensely rich in coal of various kinds. Iron is found in the coal districts, especially in Lanarkshire; the iron trade of this country, and of Scotland generally, has rapidly increased, and is now of the greatest importance. Lime and building stone are furnished in abundance. The copper and lead mines on the borders of Lanarkshire are considerable. Marble of superior quality, and slate, are produced in large quantities.

### III. *Ireland.*

The longest line that can be drawn on its surface reaches from Brow Head, in the county of Cork, to Fair Head, in Antrim, about 306 miles. The longest line that can be drawn crosswise extends from Emlagh Point, on the west coast of Mayo, to Quintin Point, on the east coast of Down, a distance of about 182 miles. But in other places the breadth is much less. The total area has been estimated at 31,875 square miles.

The surface of this country is diversified by ranges of mountains of considerable extent and elevation. The most remarkable are, the Wicklow range, with its lovely glens and valleys, which may be classed as an Alpine region; the long and lofty ranges of Slieve Bloom, Knockmeiledown, and Galty, on the borders of Leinster and Munster; and in the south-west, the towering heights of Mangerton and Macgillicuddy's Reeks, which enclose the beautiful and finely-wooded lakes of Killarney. In the north-east the Mourne Mountains equal in elevation the ranges of the south. The north-east extremity of the island presents a barrier of bold and rocky cliffs, precipitous, and of peculiar character. In the county of Antrim there is the largest basaltic formation in Europe, and the long ranges of hexagonal columns which the Giant's Causeway exhibits are unequalled in the world. The mountains on the north-west and west coast constitute a formidable barrier, that serves to attract the moisture brought from the Atlantic, and to break the rage and fury of its storms.

The coast, particularly on the west and south west, is deeply indented with bays, gulfs, and arms of the ocean, forming some noble harbours.

The central portion is occupied by a vast level, extending from east to west, quite from sea to sea. It is in some places broken by a few undulating hill ranges, and consists partly of rich cultivated land and extensive bogs; the largest of these is the Bog of Allen, in which several rivers have their sources; the highest part of this bog is elevated nearly 300 feet above the level of the sea. The peat bogs may be said to extend over one-tenth of the whole country: they are not without their value, as they supply the inhabitants with fuel. There are several extensive levels in other parts of the island; those in the counties of Tipperary and Limerick are exceedingly rich and fertile. The pasture lands on the banks of the Shannon and Fergus are said to be the finest in the United Kingdom; in short, if we deduct the mountains and bogs, the soil of Ireland, as well for agriculture as grazing, is the richest in Europe.

The rivers and loughs form a noble feature in the aspect of the country. The Shannon, which is navigable for 214 miles of its course, is without a rival in the British Isles. Many of the rivers not only afford means of internal communication, but supply large quantities of fish. The loughs are numerous and extensive; the largest is Lough Neagh, which covers an area of 100,000 acres. The Lakes of Killarney, in the south, are famed for the singular beauty and grandeur of their shores.

Ireland abounds in useful minerals, but from the want of capital to be employed in obtaining them, few are rendered available, either for home purposes or for exportation. Coal is plentiful, being found in sixteen out of the thirty-two counties. Iron is met with in many parts. In the counties of Donegal and Galway the statuary marble is nearly equal to that of Italy. The black and grey marbles of Kilkenny are of superor quality, and are exported to a considerable extent.

Copper is obtained in some districts, particularly in the vicinity of the Lakes of Killarney, in the Wicklow Mountains, and at Berehaven, in the county of Cork.

Exposed as the island is to the moisture and prevailing winds of the Atlantic, the surface is continually clad with a rich and luxuriant verdure, which has procured for it the name of "The Emerald Isle."

# CHAPTER XX.

## CONCLUSION.

We have thus endeavoured to trace a few of the phenomena connected with the earth upon which we live, and if in these outlines we have succeeded in placing before our young readers the Geography of Nature in a more pleasing and instructive form than it has hitherto been presented to them, — still more, if what we have here said has excited within them a desire to seek for further information upon the subject,—we shall have done some useful service. Independently of the practical utility of geography as a branch of instruction, it affords as good an opportunity as we can anywhere find for calling the conceptive faculty into play, and for enriching it with splendid ideas.

The claims of geography in this respect have been so forcibly urged by one of the most original and comprehensive writers of the day, that we cannot do better than conclude with his words. "What we want is to accustom the mind to stretch out from the boundary of things actually seen, and to give itself a sort of intellectual ubiquity, by the effort which realizes remote things as analogous to surrounding objects, and yet as unlike them. A child is to be led on until he breaks over his horizon; he is to be exercised and informed until he can wing his way, north or south, east or west, and can show, in apt and vivid language, that his imagination has actually taken the leap, and has returned, — whether it be from the tempest-rocked Hebrides or the ice-bound Northern Ocean; from the red man's wilderness of the west, or from the steppes of Central Asia; from the teeming swamps of the Amazon, or from the sirocco deserts of Africa, or from the tufted islets of the Pacific, or the heaving banks of Etna, or the marbled shores of Greece.

"But besides going through the characteristic scenes of the four continents, as a traveller does, we must take the earth as a whole, or as a planet, and aid the mind in looking at it as from a point of view whence it might be seen, spinning on an axis, cloud-mottled, snow-tipped, with its bulging tide wave, heading on daily from the equatorial Atlantic to the northern straits, with its steady monsoons, and its angry tornados; its fire-spitting craters, its verdant and swarming patches of life, and its red, arid expanses of sand."[*]

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[*] **Isaac Taylor's 'Home Education.'**

## LIST OF THE PRINCIPAL MOUNTAINS, WITH THEIR ELEVATIONS.

The names in larger type apply to an entire range or chain of mountains, and the height stated in such cases is an approximation to the *average* elevation which its crest attains: the names in smaller letters, where they immediately follow that of a range, are those of some of its principal summits of which the exact height has been ascertained. The figures in all cases indicate the height above the level of the sea.

The letter (V.) attached to any name, signifies that it is a volcano which has been active within the historical period.

### IN ASIA.

| | Feet. |
|---|---|
| **Aldan, or Stanovoi Mountains (Siberia):** | |
| Mount Kaplian | 4,263 |
| **Mountains of Kamtschatka:** | |
| Shievelutch (V.) | 10,591 |
| Klinchevsk (V.) | 16,512 |
| Awatshka, peak of (V.) | 8,760 |
| **Altai Mountains (Siberia and Mongolia), average height from 5,000 to 7,000 feet:** | |
| Mount Bielukha | 11,000 |
| **Thian-shan (Mongolia), from 6,000 to 8,000 feet:** | |
| Peak of Pe-shan, about | 10,000 |
| **Tsung-ling, or Kuen-lun (Tibet and Mongolia), from 16,000 to 18,000 feet:** | |
| **In-shan (Mongolia and Manchooria):** | |
| Peak of Pet-sha, above | 10,000 |
| **Yung-ling (China and Tibet):** | |
| Several snowy peaks, probably above | 12,000 |
| **Nan-ling (China):** | |
| Pass of Meilan, or Mei-ling | 8,000 |
| **Himalaya Mountains (Hindoostan and Tibet), average height from 15,000 to 18,000 feet:** | |
| Chumulari | 23,929 |
| Donkiah lah | 23,175 |
| Lachoong Pass | 18,000 |
| Kanchan-jhow | 22,000 |
| Kunchin-jinga | 28,117 |
| Wallanchoong Pass | 16,760 |
| Dhawalagiri | 26,862 |
| Jawahir | 25,670 |
| Neetee Pass | 16,814 |
| Peak of Kailas | 21,000 |
| Gangoutri Pyramid | 21,219 |
| Karakorum Pass | 18,600 |
| **Hindoo-Koosh (Afghanistan):** | |
| Koh-i-baba | 18,000 |
| **Beloor-tagh (Turkestan and Bukharia), highest peaks from 15,000 to 20,000 feet:** | |
| **Solyman Mountains (Afghanistan):** | |
| Takht-i-Solyman | 12,000 |
| **Caspian Mountains, or Chain of El-burz (Persia):** | |
| Demavend | 14,700 |
| **Mountains of Zagros (Persia and Koordistan), from 6,000 to 9,000 feet:** | |
| Peak of Rowandiz | 10,568 |
| Pass of Keli-shin, about | 9,600 |
| Jawur-tagh, highest summits of | 13,000 |
| **Mountains of Armenia:** | |
| Agri-dagh, or Mount Ararat | 17,260 |
| Mount Sevillan, about | 13,000 |
| Sapan-tagh (N. side of Lake Van), about | 10,000 |
| **Mountains of Asia Minor:** | |
| Chain of Taurus from 4,000 to 5,000 feet. | |
| Pass of Golek Boghaz, *ancient Cilician Gates* | 3,812 |
| Bulghar-dagh (western part of Taurus), about | 10,000 |
| Arjish-dagh, *ancient Argæus* | 13,100 |
| Hassan-dagh about | 9,000 |
| Kara dagh, about | 8,000 |
| Chehish-dagh *ancient Olympus*, about | 9,000 |
| Kaz-dagh, *ancient Ida* | 4,980 |
| **Mountains of Syria:** | |
| Chain of Akma-dagh *ancient Amanus* | 6,000 |
| Pass of Beilan, *ancient Syrian Gates* | 1,300 |
| Jebel Kheserik, *ancient Rhosus* | 5,400 |
| Jebel Okrah, *ancient Casius* | 5,318 |
| Chain of Mount Lebanon, from 6,000 to 7,000 feet. | |
| Jebel Libnán (highest part of Libanus), about | 9,500 |
| Jebel-esh-Sheikh, *ancient Hermon*, about | 10,000 |
| **Mountains of Sinai (Arabia):** | |
| Highest Peak | 9,300 |
| Jebel Katerin (Mount St. Catherine) | 8,593 |
| Jebel Mousa (Mount Moses) | 7,498 |
| Mount Serbal | 6,760 |

**Aravulli Mountains (Hindoostan), about 3,600 feet:**

Vindhya Mountains (ditto), from 2,500 to 3,000 feet:

Ghauts (West Coast of ditto), from 3,000 to 4,500 feet:

| | Feet. |
|---|---|
| The highest summits, about | 8,000 |
| Neilgherry Hills, or Blue Mountains | 8,960 |

## *Islands of Asia.*

| | Feet. |
|---|---|
| Japan—Mount Fusi (Island of Niphon), above | 12,000 |
| Formosa, about | 12,000 |
| Borneo—Mount Kina balow | 13,680 |
| Sumatra—Indrapura | 12,800 |
| .. Pasaman, *ancient Ophir* | 9,600 |
| Java, from 5,000 to about | 12,000 |
| Ceylon—Pedrotallagalla | 8,280 |
| .. Adam's Peak | 6,152 |
| Cyprus—Oros Troados, *ancient Olympus* | 6,590 |

## IN EUROPE.

### I. *Mountains of the Balkan System.*

Balkan Mountains (Turkey), from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Sharra tâgh | 10,000 |

Chain of Mount Pindus (Turkey and Greece), from 5,000 to 6,000 feet:

| | Feet. |
|---|---|
| Lacha, *ancient Olympus* | 9,754 |
| Kissovo, *ancient Ossa* | 6,407 |
| Zagora, *ancient Pelion* | 5,310 |
| Monte Santo, *ancient Athos* | 6,349 |
| Guiona | 8,239 |
| Liakhura, *ancient Parnassus* | 8,068 |
| St. Elias (Morea) | 7,900 |

### II. *Alpine System.*

Dinaric or Eastern Alps (Dalmatia and Croatia), from 4,000 to 5,000 feet:

| | Feet. |
|---|---|
| Mount Kom | 9,000 |
| Mount Dinara | 7,452 |
| Mount Kiek | 6,926 |

The Alps (Illyria, Styria, Tyrol, Italy, Switzerland, France), from 6,000 to 9,000 feet:

| | Feet. |
|---|---|
| Mount Terglou | 10,866 |
| Gross Glockner | 12,766 |
| Drei-herrn Spitz | 10,122 |
| Pass of the Brenner | 4,660 |
| Ortler Spitz | 12,852 |
| Pass of Mount Stelvio | 9,177 |
| Pass of the Splugen | 6,946 |
| Pass of Mount Bernardino | 7,015 |
| Mount St. Gothard | 10,595 |
| Pass of ditto | 6,808 |
| Mount Furka | 14,037 |
| Monte Leone, or the Simplon | 11,541 |
| Pass of the Simplon | 6,578 |
| Monte Rosa | 15,152 |
| Mont Cervin, or Matter-horn | 14,837 |
| Pass of Mont Cervin | 11,100 |
| Great St. Bernard | 11,006 |
| Hospice of Great St. Bernard | 7,963 |
| Pass of Great St. Bernard | 8,173 |
| Mont Blanc | 15,730 |
| Little St. Bernard | 9,591 |
| Pass of ditto | 7,192 |
| Mont Iseran | 13,274 |
| Mont Cenis | 11,460 |
| Pass of Mont Cenis | 6,775 |
| Mont Genèvre | 11,785 |
| Mont Viso | 12,586 |
| Pass of Mont Genèvre | 6,116 |

In the Bernese Alps, to the north of the Rhone:

| | Feet. |
|---|---|
| Pass of the Grimsel | 8,400 |
| Finster-aar-horn | 14,100 |
| Jungfrau | 13,718 |
| Schreck-horn | 13,386 |
| Wetter-horn | 12,210 |

Mount Jura (France and Switzerland), from 3,000 to 4,000 feet:

| | Feet. |
|---|---|
| Le Reculet | 5,627 |
| Mont Tendre | 5,541 |

The Apennines (Italy), from 3,000 to 5,000 feet:

| | Feet. |
|---|---|
| Monte Cimone | 6,975 |
| Monte Sybilla | 7,212 |
| Monte Corno | 9, 21 |
| Mount Vesuvius | 3,932 |

### III. *Carpathian System.*

Southern Carpathians (Transylvania and Wallachia):

| | Feet. |
|---|---|
| Puyana-Ruska | 9,912 |
| Valkan Pass | |
| Rother-thurm Pass | |
| Szurul | 7,874 |
| Torzburg Pass | |
| Bukhest | 8,700 |
| Tomos Pass | |

Carpathian Mountains (Transylvania, Hungary, Moldavia, and Galicia), from 5,000 to 6,000 feet:

| | Feet. |
|---|---|
| Mont Tatra | 8,524 |
| Pass of Jablunka | |
| Range of Mount Matra | 3,312 |

### IV. *Hercynian System.*

Sudetic Mountains (Silesia, Moravia, and Bohemia), from 3,000 to 4,000 feet:

| | Feet. |
|---|---|
| Schneeberg | 4,784 |

Riesen Gebirge (Silesia and Bohemia), from 3,000 to 4,000 feet:

| | Feet. |
|---|---|
| Schnee-kopf | 5,274 |

Erz Gebirge (Saxony and Bohemia), from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Sonnen-wirbel | 4,[illegible] |

Märische Gebirge (Bohemia and Moravia), 2,178 feet:

Böhmer Wald (Bohemia and Bavaria), from 3,000 to 4,000 feet:

| | Feet. |
|---|---|
| Rachelberg | 4,561 |

Fichtel Gebirge (Bavaria):

| | Feet. |
|---|---|
| Schneeberg | 3,461 |

Thuringer Wald (Sachsen-Coburg and Hessen-Cassel), from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Schnee-kopf, or Beerberg | 3,075 |

Harz Mountains (Hanover):

| | Feet. |
|---|---|
| Brocken | 3,658 |

Schwarz-wald (Baden), from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Feldberg | 4,675 |

### V. *Mountains of France.*

Chain of the Cevennes, from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Mont Lozère | 4,884 |
| Mont Mezin | 5,819 |
| Mont Tarare | 4,735 |

Plateau of Langres, about 1,000 feet:

Chain of the Vosges, from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Ballon d'Alsace | 4,124 |
| Ballon de Sultz | 4,698 |
| Donnersberg | 2,225 |

The Ardennes, about 1,800 feet:

Mountains of Forez:

| | Feet. |
|---|---|
| Pierre sur Haute | 5,485 |

Mountains of Auvergne:

| | Feet. |
|---|---|
| Plomb du Cantal | 6,093 |
| Puy de Sancy, summit of Mont Doré | 6,221 |
| Puy de Dôme | 4,846 |

### VI. *Mountains of the Spanish Peninsula.*

The Pyrenees (France and Spain), from 7,000 to 9,000 feet:

| | Feet. |
|---|---|
| Pass de Rat | 7,473 |
| Montcal | 10,663 |
| Pic de Nethou | 11,426 |
| Pass of Venasques | 7,917 |
| Mont Perdu | 10,994 |
| Pass of Gavarnie | 7,654 |
| Pic du Midi | 9,540 |

Cantabrian Mountains, from 4,000 to 6,000 feet:

| | Feet. |
|---|---|
| La Pena de Penaranda | 10,998 |

Celtiberian Mountains:

| | Feet. |
|---|---|
| Sierra d'Oca | 5,450 |
| Sierra Molina | 4,500 |

Castilian Chain, from 4,000 to 5,000 feet:

| | Feet. |
|---|---|
| Pass of the Somo Sierra | 4,944 |
| Palace of the Escurial | 3,264 |
| Sierra de Gredos | 10,548 |
| Sierra d'Estrella, Portugal | 7,524 |

Mountains of Toledo, from 3,000 to 4,000 feet:

| | Feet. |
|---|---|
| Sierra de Guadalupe | 5,115 |

Sierra Morena, from 2,000 to 3,000 feet:

| | Feet. |
|---|---|
| Puerto de Rey | 2,274 |
| Sierra Monchique, Portugal | 4,079 |

Sierra Nevada, from 6,000 to 9,000 feet:

| | Feet. |
|---|---|
| Peak of Mulhacen | 11,657 |
| Peak of Veleta | 11,389 |
| The Alpuxarras | 9,165 |
| Rock of Gibraltar | 1,437 |

### VII. *The Scandinavian Mountains.*

| | Feet. |
|---|---|
| Hardanger-field | 5,748 |
| Pass of Fille-field | 3,975 |

Langfield:

| | Feet. |
|---|---|
| Skagstol-tind | 8,101 |

Dovre-field:

| | Feet. |
|---|---|
| Snee-häetten | 8,120 |
| Sylfiellen | 6,486 |

Koelen Mountains:

| | Feet. |
|---|---|
| Sulitelma | 6,178 |
| North Cape (Island of Mageröe) | 1,161 |

### VIII. *The Ural Mountains.*

Chain of the Ural, from 2,000 to 2,500 feet:

| | Feet. |
|---|---|
| Konjakovski | 5,397 |
| Yaman | 5,400 |
| Iremel | 5,075 |

### IX. *Caucasian System.*

Chain of Mount Caucasus, from 8,000 to 9,000 feet:

| | Feet. |
|---|---|
| El-burz | 18,493 |
| Kasbek | 16,530 |
| Pass of Dariel | 8,000 |
| Chatyr-dagh, highest point | 5,110 |

### *Islands of Europe.*

British Islands:

| | Feet. |
|---|---|
| Ben Wyvis (Northern Highlands of Scotland), *Ross* | 3,720 |
| Ben Macdhui, (Grampians), *Aberdeen* | 4,390 |
| Ben Nevis, (do.), *Inverness* | 4,378 |
| Ben Lawers, (do.). *Perth* | 3,945 |
| Ben Lomond, (do.). *Stirling* | 3,191 |
| Sidlaw Hills, *Perth and Forfar*, highest point | 1,406 |
| Ben Clach, (Ochill Hills), *Clackmannan* | 2,359 |
| Pentland Hills, *Edinburgh and Lanark* | 1,860 |
| Spartledown, (Lammermuir Hills), *Haddington* | 1,700 |
| Mistie Law, *Renfrew* | 1,558 |
| The Lowthers (Lowther Hills), *Lanark* | 3,150 |
| Queensberry Hill (do.), *Dumfries* | 2,259 |
| Hart Fell (do.), *Dumfries and Peebles* | 2,635 |
| Ettrick Pen (do.), *Selkirk* | 2,258 |
| Cheviot, (Cheviot Hills), *Northumberland* | 2,658 |
| Cross Fell, (Pennine Chain), *Cumberland* | 2,901 |

| | Feet. |
|---|---|
| Whernside, (Pennine Chain), *Yorkshire* | 2,384 |
| Ingleborough do. *do.* | 2,361 |
| Pen-y-gent do. *do.* | 2,270 |
| Pendle Hill (do.), *Lancashire* | 1,803 |
| Kinderscout, highest point of the Peak (do.), *Derby* | 1,981 |
| Axe-edge Hill (do.), *Derby* | 1,751 |
| Weaver Hills (do.), *Stafford* | 1,154 |
| Scaw Fell (Cumbrian Mountains), *Cumberland* | 3,166 |
| Helvellyn (do.) *do.* | 3,055 |
| Skiddaw (do.) *do.* | 3,022 |
| Burton Head (York Moors), *Yorkshire* | 1,485 |
| Wilton Beacon (The Wolds), *do.* | 809 |
| The Wrekin, *Shropshire* | 1,320 |
| Clee Hills, *do.* | 1,805 |
| Clent Hills, *Worcester* | 1,007 |
| Malvern Hills, *Worcester and Hereford* | 1,444 |
| Cleeve Hill (Cotswolds), *Gloucestershire* | 1,134 |
| Kensworth Hill (Chiltern Hills), *Hertford* | 904 |
| Inkpen Beacon (North Downs), *Berks and Hants.* | 1,011 |
| Leith Hill (do.), *Surrey* | 993 |
| Butser Hill (South Downs), *Hants* | 917 |
| Mendip Hills, *Somerset* | 1,100 |
| Cawsand Beacon (Dartmoor), *Devon* | 1,792 |
| Brown Willy (Cornish Hills, *Cornwall* | 1,368 |
| Snowdon (Welsh Mountains) | 3,571 |
| Plinlimmon, (do.) | 2,463 |
| Slieve Donard (Mourne Mountains), *Ireland* | 2,796 |
| Lugnaquilla (Mountains of Wicklow), *do.* | 3,039 |
| Macgillicuddy's Reeks (Mountains of Kerry), *do.* | 3,404 |
| Goat Fell (Island of Arran) | 2,866 |
| Paps of Jura (Island of Jura), *Hebrides* | 2,470 |
| Ben-more (Island of Mull), *do.* | 3,168 |
| Cuchullin (Island of Skye), *do.* | 2,995 |
| Hecla (Island of South Uist), *do.* | 2,940 |
| Clisseval (Island of Lewis), *do.* | 2,700 |
| Highest point of Hoy Island (Orkney Islands) | 1,590 |
| Mount Rona, Mainland, (Shetland Islands) | 1,470 |

### Iceland:

| | |
|---|---|
| Snaefell | 6,862 |
| Hecla (V.) | 5,210 |

### Azores, or Western Islands:

| | |
|---|---|
| Grand Pico | 8,057 |

### Corsica:

| | |
|---|---|
| Monte Rotondo | 9,069 |

### Sardinia:

| | |
|---|---|
| Monte Schiuschiu, about | 6,000 |

### Sicily:

| | |
|---|---|
| Etna (V.) | 10.874 |

### Candia:

| | |
|---|---|
| Psiloritti, *ancient Ida* | 7,800 |

## IN NORTH AMERICA.

### Rocky Mountains:

| | |
|---|---|
| Mount Brown (lat. 52° 35'), about | 15,990 |
| Mount Hooker (lat. 52° 15'), about | 15,700 |
| Long's Peak (lat. 40° 20') | 13,575 |
| James's Peak (lat. 38° 50') | 11,820 |

### Sierra Nevada, or Snowy Mountains (California), probably above 10,000 feet:

### West Coast Mountains (New Caledonia, Oregon, and California):

| | Feet. |
|---|---|
| Mount St. Elias (lat. 60° 20', long. 140° 30' W.) | 17,900 |
| Mount Fairweather (lat. 58° 2') | 14,730 |
| Mount St. Helens (lat. 46°), about | 13,300 |
| Mount Hood (lat. 45° 3'), about | 12,000 |

### On the Table-lands of Mexico and Central America:

| | |
|---|---|
| Orizaba (V.) lat. 19° 3', long. 97° 11' W.) | 17,373 |
| Popocatepetl (V.) lat. 18° 59', long. 98° 30' | 17,884 |
| Toluca (lat. 19° 9', long. 99° 36') | 15,171 |
| Colima (V.) lat. 19° 4', long. 103° 7'. | 9,188 |
| Jorullo (V.) lat. 18° 54', long. 101° 30' | 4,114 |
| Agua (V.), Guatemala | 12,300 |

### Alleghany or Apalachian Mountains, from 2,500 to 3,000 feet:

| | |
|---|---|
| Mount Washington, (White Mountains), *New Hampshire* | 6,234 |
| Peaks of Otter, *Virginia* | 4,260 |
| Unaka or Iron Mountains, *North Carolina* | 6,476 |

## IN SOUTH AMERICA.

### The Andes, or Cordilleras de los Andes: between 5° N. lat. and 2° S. lat., from 11,000 to 12,000 feet; between 15° and 19° S. lat., about 15,000 feet; southward of 42° lat., about 3,000 feet:

| | |
|---|---|
| Tolima (lat. 4° 48' N.) | 18,314 |
| Cayambe (lat. 0° 4' S.) | 19,625 |
| Antisana (V.) lat. 0° 30' S.) | 19,136 |
| Cotopaxi (V.) lat. 0° 39' S. | 18,858 |
| Chimborazo (lat. 1° 22' S.) | 21,415 |
| Sorata (lat. 15° 40' S.) | 21,284 |
| Sahama (Bolivian Andes) | 22,350 |
| Aconcagua (V.) lat. 32° 40' S.) | 23,910 |

### Mountains of Venezuela, from 4,000 to 5,000 feet:

| | |
|---|---|
| Sierra de Merida (lat. 8° 6' N., long. 71° 10' W.) | 16,420 |
| Silla de Caraccas | 8,630 |

### Mountains of Parime or Guiana, from 4,000 to 5,000 feet:

| | |
|---|---|
| Maravaca (lat. 3° 40' N., long. 65° 47' W.), about | 11,000 |
| Duida, or la Esmeralda (lat. 3° 17' N., long. 65° 40' W.) | 8,276 |
| Roraima. | 7,450 |

### Mountains of Brazil, from 2,000 to 3,000 feet:

| | |
|---|---|
| Sierra Mantiqueira, highest summit. | 5,496 |
| Itacolumi (lat. 20° 20' S.) | 5,750 |

### *Islands of America.*

| | Feet. |
|---|---|
| **West Indies:** | |
| Cuba: Sierra de Cobre | 8,600 |
| Jamaica: Blue Mountains, above | 7,000 |
| Hayti: Mountains of Cibao | 8,600 |
| Porto Rico: Sierra de Languilla | 8,678 |
| Guadaloupe: Souffrière (V.) | 5,500 |
| Dominica: Highest Peak | 6,000 |
| Martinique: Mount Pelée | 4,400 |
| St. Lucia: Gros Piton | 2,710 |
| St Vincent: Morne Garou | 4,800 |
| **Terra del Fuego:** | |
| Mount Sarmiento | 6,800 |

### In Australia and Polynesia.

| | Feet. |
|---|---|
| **Australia:** | |
| Mount Lindesay (lat. 28° 16′ S., long. 152° 45′ E.) | 5,700 |
| Canobolas (lat. 33° 21′ S., long. 149° 1′ E.) | 4,461 |
| Blue Mountains, highest point of | 3,242 |
| Australian Alps, or Warragong Mountains, highest point | 6,500 |
| Darling Range, West Coast, of, about | 2,500 |
| **Tasmania:** | |
| Wyldes Crag | 4,500 |
| **New Zealand:** | |
| Mount Egmont | 8,838 |
| **Society Islands:** | |
| Tahiti, highest point | 12,250 |
| **Sandwich Islands:** | |
| Mowna Koa (V.) Owhyhee | 13,764 |
| Mowna Roa (V.) do. | 13,480 |
| **South Victoria:** | |
| Mount Erebus (V.) | 12,400 |

## LIST OF THE PRINCIPAL RIVERS WITH THEIR CHIEF TRIBUTARIES.

### *Showing their Sources—the Countries through which they flow—the Seas into which they fall—and their Approximate Length in English Miles.*

After the name of each river follow,—1st (between parentheses), that of the district in which it rises;—2nd, the name of its principal tributaries; 3rd (*in italics*), the countries through which it flows;—4th, the sea or ocean into which it falls; and lastly, its length, when ascertained.

### In Asia.

| | Miles. |
|---|---|
| Obi (Altai Mountains), Irtish, Ishim, Tobol;* *Siberia:* Arctic Ocean | 2,530 |
| Yenesi (do.) Upper Tungouska or Angara, Middle Tungouska, Lower Tungouska: *Siberia:* Arctic Ocean | 2,900 |
| Lena (Altai Mountains), Vitim, Olekma, Aldan, Vilini: *Siberia:* Arctic Ocean | 2,400 |
| Amour (Plateau of Mongolia), Songari: *Mongolia, Manchouria:* Gulf of Tartary | 2,300 |
| Hwang-ho (Kuenlun Mountains), Wei-ho: *China:* Yellow Sea | 2,600 |
| Yang-tsze-kiang (do.) Yuen-kiang, Han-kiang: *China:* Yellow Sea | 3,200 |
| Choo-kiang (Nan-ling Mountains).—*China:* Chinese Sea. | |
| May-kuang or Mekon (Plateau of Tibet),—*Tibet, China, Cambodia:* Chinese Sea. | |
| Meinam (Mountains of Yunnan),—*China, Laos, Siam:* Gulf of Siam. | |
| Saluen (Plateau of Tibet),—*Tibet, China,* between *Birmah* and *Siam:* Gulf of Martaban. | |
| Irawaddy (Plateau of Tibet),—*Birmah:* Bay of Bengal | 1,200 |
| Brahmapootra (do.), Di-hong:† *Assam, Hindoostan:* Bay of Bengal. | |
| Ganges (Himalaya Mountains), Jumna, Goomtee, Gogra, Sone, Gunduck, Coosy: *India:* Bay of Bengal | 1,400 |
| Mahanuddy (Plateau of Deccan),—*India:* Bay of Bengal. | |
| Godavery (Ghauts),—*India:* Bay of Bengal. | |
| Krishna (do.) *do.* do. | |
| Cauvery (do.) *do.* do. | |
| Taply (Plateau of Deccan),—*India:* Gulf of Cambay. | |
| Nerbudda (do.) *do.* do. | |
| Indus (Plateau of Tibet), Caubul, Chenaub, Jelum, Ravee, Sutlej, Beas:‡ *India:* Arabian Sea | 1,700 |
| Euphrates (Plateau of Armenia), Tigris. *Al-Jezireh, Irak-Arabi:* Persian Gulf | 1,600 |

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* The Ishim and Tobol, though *tributaries* of the Obi, are not properly its affluents, since they both terminate in the Irtish, above the junction of that river with the main stream of the Obi.

† The Di-hong is *probably* the same river as the San-poo of Tibet, which flows along the northern base of the Himalaya Mountains: this, however, is not ascertained.

‡ The Jelum, Ravee, and Sutlej, are affluents of the Chenaub; and the Beas is an affluent of the Sutlej: these streams flow through the Punjaub, *i. e.* the country of the Penj-ab, or five rivers.

Miles.
Jordan (Mountains of Lebanon), Hieromax, Jabbok: *Palestine:* Dead Sea . . . . . . *287
Kour (do.) Aras: *Georgia:* Caspian Sea.
Ural or Iaik (Ural Mountains),—*between Europe and Asia:* Caspian Sea.
Amoo or Jihoon (Plateau of Pamer).—*Turkestán:* Sea of Aral . . . . . . . . . . 1,300
Sir or Sihoon (Mooz-tagh),—*Turkestán:* Sea of Aral.
Helmund (Hindoo Koosh),—*Affghanistán:* L. Zurrah.
Tarim or Ergheu (Plateau of Pamer),—*Little Buchharia:* L. Lop.

## In Africa.

Nile (Plateau of Central Africa), Abai or Bahr el-Azrek,† Tacazze: *Donga, Nubia, Egypt:* Mediterranean Sea.
Senegal (Mountains of Western Soudan),—*Senegambia:* Atlantic Ocean.
Gambia (do.) *do.* do.
Quorra or Niger (do.) *do.* Quarrama, Coudonia, Chadda: *Soudan:* Gulf of Guinea.
Zaire or Congo (Plateau of Central Africa),—*Congo:* Atlantic Ocean.
Coanza (do.) *Angola:* do.
Gariep or Orange River (Mountains of South Africa), Fish Biver: *South Africa:* Atlantic Ocean . . . . . . . . . . . . . . . . . . . . . . . . . . 1,050
Zambesi (Interior of Africa),—*East Africa:* Indian Ocean.

## In Europe.

Volga (Plateau of Valdai), Mologa, Oka, Kama: *Russia:* Caspian Sea . . . . . . . . 2,200
Don (Great European Plain).—*Russia:* Sea of Azov . . . . . . . . . . . . . . 1,100
Dniepr (do.) Pripet, Boug: *Russia:* Black Sea. . . . . . . . . . 1,200
Dnieste (Carpathian Mountains),—*Galicia, Russia:* do.
Danube (Schwarz Wald), Inn, March or Morava, Drave, Theiss, Save, Marava, Aluta, Pruth. *Germany, Hungary, Turkey:* Black Sea . . . . . . . . . . . . . . 1,630
Po (Alps), Ticino, Adda, Mincio: *Italy:* Adriatic Sea . . . . . . . . . . . . 450
Tiber (Apennines),—*Italy:* Mediterranean Sea.
Rhone (Alps), Saone: *Switzerland, France:* Mediterranean Sea . . . . . . . . . 490
Ebro (Cantabrian Mountains),—*Spain:* do. . . . . . . . . . 420
Guadalquiver (Table-land of Spain),—*Spain:* Atlantic Ocean . . . . . . . . 290
Guadiana (do.) *Spain, Portugal:* Atlantic Ocean . . . . . . 450
Tagus (do.) *do.* do. . . . . . . 510
Douro (do.) *do.* do. . . . . . . 460
Garonne (Pyrenees), Tarn, Lot, Dordogne: *France:* Bay of Biscay . . . . . . . . 350
Loire (Cevennes), Allier, Cher, Indre, Vienne: *do.* do. . . . . . . . 570
Seine (Plateau of Langres), Aube, Yonne, Marne, Oise: *France:* English Channel . . . 480
Scheldt (Plain of Northern France),—*France, Belgium:* German Ocean.
Rhine (Alps), Aar, Neckar, Maine, Moselle, Meuse: *Switzerland, Germany, Holland:* German Ocean . . . . . . . . . . . . . . . . . . . . . . . . . 760
Weser (Hercynian Mountains),—*Germany:* German Ocean.
Elbe (do.) *do.* do. . . . . . . . . . . . . . . 690
Oder (do.) *do.* Baltic Sea . . . . . . . . . . . . 550
Vistula (Carpathian Mountains),—*Poland, Prussia:* do. . . . . . . . . . . . 628
Niemen (Great European Plain),—*Russia Prussia:* do.
Dwina (Plateau of Valdai),—*Russia:* Gulf of Riga. . . . . . . . . . . . . . 350
Neva (from L. Ladoga), *do.* Gulf of Finland . . . . . . . . . . . . . . 45
Tornea, Lulea, Pitea, Umea, Indals, Dal, (Scandinavian Mountains),—*Sweden:* Baltic Sea.
Gota (from L. Wener). *Sweden:* Kattegat . . . . . . . . . . . . . . . . 58
Glommen (Scandinavian Mountains), *Norway:* Skager-rack.
Dvina (Great European Plain),—*Russia:* White Sea . . . . . . . . . . . . . 760
Petchora (Ural Mountains), *do.* Arctic Ocean.
Spey (Grampian Mountains), Avon: *Scotland:* North Sea . . . . . . . . . . . 96
Don (do.) *do.* do. . . . . . . . . . . . . . 65
Dee (do.) *do.* do. . . . . . . . . . . . . . 87
Tay (do.) Tumel, Isla, Earn: *do.* German Ocean . . . . . . . . . . . 95
Forth (Grampians),—*Scotland:* German Ocean. . . . . . . . . . . . . . . 50
Tweed (Lowther Hills), Ettrick, Lauder, Teviot, Till: *Scotland, between England and Scotland:* German Ocean . . . . . . . . . . . . . . . . . . . . . . 96
Tyne (Pennine Chain),—*England:* German Ocean. . . . . . . . . . . . . . 70
Wear (do. *do.* do. . . . . . . . . . . . . . 60
Tees (do. *do.* do. . . . . . . . . . . . . . 75

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* The entire length of the valley of the Jordan does not exceed 106 miles; but the river is extremely winding, so much so that between the Lake of Tiberias and the Dead Sea (a direct distance of only 68 miles) it flows nearly 200 miles. Numerous rapids occur in this portion of its course.

† At Khartoum (lat. 15° 34′ N.), the two branches of the Nile unite; the eastern of these is distinguished as the Bahr el-Azrek or Blue River, and the western as the Bahr el-Abiad, or White River. The latter is the longer, and is now generally regarded as the true Nile; its source has not yet been explored, but the entire length of the river by this branch is probably not less than 3,500 miles. The Bahr el-Azrek rises in the Mountains of Abyssinia; from *this* source to the Mediterranean the Nile measures about 2,600 miles.

Mile

Humber . . { Ouse, (Pennine Chain), Yore, Wharfe, Derwent, Aire, Don: . . . . . . . . . . . 110
Trent, (Staffordshire Moorlands), Tame, Dove, Derwent, Soar: . . . . . . . . . . . 140 } *England:* German Ocean. } 180
Witham (Central Plain),—*England:* The Wash . . . . . . . . . . . . . . . 75
Welland (do.) *do.* do. . . . . . . . . . . . . . . . 60
Nen (do.) *do.* do. . . . . . . . . . . . . . . . 85
Ouse (do.) *do.* do. . . . . . . . . . . . . . . . 145
Thames (Cotswold Hills), Cherwell, Thame, Kennet, Lea, Medway. *England:* German Ocean. . . . . . . . . . . . . . . . . . . . . . . . . 215
Severn (Welsh Mountains), Virnwy, Teme, Avon, Wye: *Wales, England:* Bristol Channel 240
Dee (Welsh Mountains),—*Wales, England:* Irish Sea.
Mersey (Pennine Chain), Irwell; *England:* do. . . . . . . . . . . . . . . 170
Eden (do.) *England:* Solway Firth . . . . . . . . . . . . . . . 80
Clyde (Lowther Hills).—*Scotland:* Firth of Clyde. . . . . . . . . . . . . . . 98
Liffey (Mountains of Wicklow).—*Ireland:* Irish Sea . . . . . . . . . . . . . . 75
Barrow (Slieve Bloom Mountains), Nore: *Ireland:* Waterford Harbour . . . . . . . 105
Suir (do.) *do.* do. . . . . . . . 100
Shannon (Mountains of Cavan), Suck: *do.* Atlantic Ocean . . . . . . . . . 224
Boyne (Central Plain),—*Ireland:* Irish Sea . . . . . . . . . . . . . . . . . . 80

## In North America.

Mackenzie (Great Slave Lake), River au Liards: *British America:* Arctic Ocean.
Churchill or Missinippi (Central Plain of North America). *do.* Hudson's Bay.
Nelson (Lake Winnipeg),—*British America:* Hudson's Bay.
St. Lawrence (Lake Ontario), Ottawa, Richelieu: *Canada:* Gulf of St. Lawrence . . . . 692
Hudson (Saranack Mountains), Mohawk: *United States:* Atlantic Ocean . . . . . . . 325
Delaware (Catskill Mountains), Schuylkill: *United States:* Atlantic Ocean . . . . . . 300
Susquehannah (Alleghany Mountains), *do.* Chesapeake B. . . . . . . 500
Potomac (do.) *do.* do. . . . . . . . 400
James River (do.) *do.* do. . . . . . . . 450
Mississippi (Lake Itaska), St. Peter's Wisconsin, des Moines, Missouri, Ohio, Arkansas, Red River: *United States:* Gulf of Mexico . . . . . . . . . . . . . . . . . . . . 2,400
Ditto, Missouri Branch (Rocky Mountains), Yellow-stone, Platte, Kanzas: *U. S. Territory:* total length, by this branch, about . . . . . . . . . . . . . . . . . . 4,000
Del Norte (Rocky Mountains), Puercos: *between Texas and Mexico:* Gulf of Mexico.
Colorado (do.) Gila: *California:* Gulf of California.
Sacramento (Sierra Nevada), San Joaquim: *California:* Pacific Ocean.
Oregon or Columbia (Rocky Mountains), Wallamet, des Chutes, Lewis or Snake, Flathead, Koutani; *Oregon Territory:* Pacific Ocean . . . . . . . . . . . . . . . . . . 1,200

## In South America.

Magdalena (Andes), Cauca: *New Granada:* Carribean Sea . . . . . . . . . . . 860
Orinoco (Parime Mountains), Ventuari, Guaviari, Meta, Araucu, Apure, Caura: *Venezuela:* Atlantic Ocean. . . . . . . . . . . . . . . . . . . . . . . . . . 1,200
Essequibo (Sierra Acaray), Massaroony, Cuyuni: *British Guayana:* Atlantic Ocean.
Demerara (Sierra Acaray),—*British Guayana:* Atlantic Ocean.
Berbice (do.) *do.* do.
Corentyn (do.) *between British and Dutch Guayana:* Atlantic Ocean.
Surinam (Sierra Acaray),—*Dutch Guayana:* Atlantic Ocean.
Amazon or Maranon (Andes), Huallaga, Ucayali, Napo, Yavari, Putumayo, Yutay, Yurua, Yapura, Teffe, Purus, Negro, Madeira, Tapajos, Xingu, Tocantins: *Peru, between Peru and Equador, Brazil:* Atlantic Ocean . . . . . . . . . . . . . . . . . . . 3,900
San Francisco (Mountains of Brazil),—*Brazil:* Atlantic Ocean . . . . . . . . . 1,500
De la Plata . { Parana (do.) Paranahyba. Iguassu, Paraguay, Salado: *Brazil, Paraguay, and La Plata:* Atlantic Ocean. . . . . . . . . . . 2,350
Uruguay (do.) *Brazil, between Banda Orientale and La Plata.*

## In Australia.

Brisbane, Lagan, Clarence, Mac Leay, Hastings, Manning, Hunter, Hawkesbury, Shoalhaven; (Mountains of the East Coast),—*New South Wales:* Pacific Ocean.

## In Tasmania or Van Diemen's Land.

Derwent (L. St. Clair), Pacific Ocean . . . . . . . . . . . . . . . . . . 130
Tamar,—Bass's Strait.

## In New Zealand.

Wai-hou or Thames,—*East Coast of North Island:* Gulf of Hauraki, Pacific Ocean.
Waikato,—*West Coast:* Pacific Ocean . . . . . . . . . . . . . . . . . . 218
Wanganui,— *do.* do

# APPENDIX.

## ON CERTAIN POINTS OF GEOGRAPHICAL TEACHING.

BY R. G. LATHAM, M.A., M.D., F.R.S., &c.

# APPENDIX.

**It is the special object of the present notice to suggest to the teacher of geography the propriety of making the *explanation of the meaning of geographical terms part and parcel of his teaching*. If he do this he will find his advantage in two respects.**

**1. In the first place, the simple fact of a certain word having a certain meaning will constitute the very smallest part of what the student learns. It will introduce, or carry with it, a great many other points of knowledge besides.**

**2. In the second, it will do more to make a map a source of pleasure than can be done by any other mode of teaching.**

**But it may be asked have all geographical terms a meaning, and is that meaning capable of being shown?**

To this I answer that the generality of local terms are not *Proper*, so much as they are *Common*, names; that, as such, they almost always have a meaning; that the compound forms which they exhibit are generally capable of analysis; and that the signification of their different elements is often (not always) intelligible.

The following three words are sufficient to explain the subject:—

| | | |
|---|---|---|
| *Stow* . . . | *Place* . . | *English.* |
| *Novo-gorod* . | *New-town* . | *Russian.* |
| *Punj-ab* . . | *Five-rivers* . | *Hindu.* |

In the first column we have an ordinary geographical name, *e. g. Stow-on-the-Wold*, in Glo'stershire; *Novogorod*, in Russia; and the *Punjab*, in the East Indies.

In the second we have the meaning of it;

And in the third the language to which the word belongs —the language in which its meaning has to be sought. Thus *stow* is an English word, as truly as *Novogorod* and *Punjab* are Russian and Indian; and its meaning is *place*, as truly as *novo-* means *new; -gorod, town: punj-, five*, and *-ab, river.*

*Stow* is truly an English word, although, when it appears as the name of a place, it is not every Englishman that understands its signification. Indeed, English though it be, its use as an ordinary *substantive* is rare. As a *verb* it is common. When we say *stow those things away*, we mean *place* (or *lay*) *them away*. It occurs, too, in the compound be-*stow*.

In fact, *stow* the substantive is an English word, but obsolete. In the Anglo-Saxon stage of the English language it was as common as our word *place* is now, so that if the geographer choose to call it *Anglo-Saxon* or *Old English*, instead of simply *English*, he is free to do so. *English*, however, is sufficiently accurate for all practical purposes.

Now to illustrate the use of this:—

*Stow*, as aforesaid, means *place*; and the language it belongs to is the English. It is the teacher's business to know this and to tell it to the pupil. Let the pupil, then, take a map of Great Britain, and be told to look out for the different places named *Stow* which it supplies. He will find a certain number, *e. g.*, in Bucks, in Glo'stershire, in Lincolnshire, &c. He will find few or none in Wales. (Let him discover this for himself if he can.) Why are there few or none in Wales? Because in Wales the language is no longer English. What does he find in Wales? A number of words beginning with *llan-*, *tre-*, *pen-*, &c. Tell him now to find these in England. He will not do it very easily, though he will do it with pains. It is submitted that there is something in an exercise of this kind which both interests the mind and stimulates inquiry. At any rate, it enables the learner to work certain map-problems by himself.

On the other hand, the teacher must be thoroughly master of his work; the simple knowledge of the meaning of a given term, and the power of analyzing a compound, being the least important part of his information. This can often be dispensed with; indeed, in many cases it cannot be attained. The truly important part of his business is to know what names are the most suggestive of collateral points of knowledge, and in what direction the attention of the pupil who employs himself on the map should be turned.

*a.* What can be done with such a word as *stow* can be done with many others.

*b.* What can be done with such a word as *stow* and many others in Great Britain can be done *in every part of the world* —more or less.

It can be done in every part of the world, though not always with equal accuracy and fulness.

It can be done in every part of the world and in maps of all ages—in the ancient map, illustrative of classical and scriptural antiquity, and in the map of the present year.

It can be done with maps of all ages, though not always with equal fulness and accuracy.

In the present sketch—

A. It will be shown, *in somewhat full detail*, how it can be done in the *British islands*, and

B. It will be shown, *briefly and in a cursory manner*, how it can be done *elsewhere all over the world.*

We begin with the *English* part of the British Islands, as opposed to the Welsh, or British, and to the Scotch and Irish Gaelic. The words which come under notice we may call either *English* or *Anglo-Saxon*. This is a matter of indifference. It is only important to remember that they are of considerable antiquity, and go back to the Anglo-Saxon times of Edward, Alfred, and even earlier. Of course, the older forms are not exactly identical with the newer—*e. g.*, the Anglo-Saxon forms for such words as *Ox-ford*, *Staun-ton*, or *Swines-head*, are *Oxna-ford*, *Stân-tún*, or *Swines-heafod.* Nevertheless, the difference is unimportant.

*Stow* was a simple single word meaning *place*. *Novo-gorod* and *Punj-ab* were compounds = *New-town* (*New-ton*) and *Five-rivers.* As a general rule, English geographical names *are compound rather than simple.* *Stow* itself appears oftener in such words as Bri-*stow*, Wit-*stow*, Long-*stow*, &c., than it does by itself.

In compound words there are, of course, two or more parts or elements. Of these, *the last is the most important.*

The last of the elements in an English compound is mostly a name like *-ford*, *-fleet*, *-ham*, &c., a name of wide and common signification—a *general* name; whereas the first is a kind of definition, limiting this general name to one particular application—*Ox*-ford, *North*-fleet, *Wick*-ham. (This may be enlarged on as a point of grammar.)

Sometimes the meaning of both elements is equally clear, as *Oak-ley*, *North-wick*, *New-town*, &c. As a general rule, however, the latter or more general element is the one easiest explained, and to the consideration of that the teacher may, generally, restrict himself. The second word is often "the description either of a natural feature of the country, a hill, a stream, a ford, or of an artificial construction. The distinctions between even the slightest differences in the face of the country are marked with a richness and accuracy of language which will surprise all those who have not noticed a similar phenomenon in the remote provinces of England. On the other hand, the artificial constructions enable us to glance at the private life, as it were, of the people; to argue upon their mode of culture, their enclosures, hedges, weirs, barns, houses, mills, mines, quarries," &c. &c. — (Kemble, in *Codex Diplomaticus Ævi Saxonici*, vol. iii.)

All this is suggestive; suggestive of ideas respecting the arts and habits of our ancestors; suggestive, too, of something else in the way of a caution against looking for names in unlikely quarters. No man would seek for compounds of such words as *hill* or *rock* in a fenny district, or compounds of such words as *fen* or *moor* amongst mountains. The character of the country must always be borne in mind.

The compounds most deserving notice in English are :—

*Beck* = *brook*, as in Wel-*beck*, &c. It is commoner in the North of England than in the South. Trace it in the direction of Northern Germany, Norway, Sweden, and Denmark. It will still appear as beck (Eims-beck, &c). In Southern Germany it becomes *bach;* as Schwal-*bach*. Nevertheless, as beck or ba*ch* it is found over both Germany and Scandinavia as well as in England.

*Bridge*.—Such words as Stanny-*bridge* and *Stan*-bridge = *stone*-bridge. As these compounds are as old as the time of the Saxons, occurring in more than one of the Anglo-Saxon charters, we learn that our forefathers made their bridges of *stone*. Special mention is made of the *stænene brycg*, and the *stân brycg*. But not to the exclusion of the ruder *wooden* one; inasmuch as there is a *wudu*-brycg (*Wood*-bridge) as well.

*Borough* (*burg*).—When spelt with *u* this means *city*, *town*, *borough*, as in Peter-*borough*. In Anglo-Saxon this was *buruh* or *burh*, and (for there were genders in those days) it was a word of the *feminine* gender. But berg with *e* means *hill*, as in ice-*berg*. In Anglo-Saxon this was *beorh*, and its gender was the *masculine*. The compounds in berg are rarer in English than those in burg. Trace both over Germany, distinguishing between the forms.

*Den* (as in Gads-*den*, &c.) The *den*-s are particularly common in Kent, not uncommon in other parts of England (Beds, Herts, and Hunts), rare in Germany. It has two origins—one from *denu* = *valley*, a word of the feminine gender, the other from *den* =(generally) a *swine-pasture*. A.D. 1659, there were not less then 32 *dens* in Kent; and there was a *Court of Dens* held at Aldington. These run chiefly along the edge of the Weald—just the place where swine would find beech-mast or acorns for their pasture.

*Fleet.*—Like *stow*, this word is found both alone and in composition—the *Fleet* (river), *Fleet* in Lincolnshire, North-*fleet*. It means *stream*. To be looked for in Germany, Scandinavia, and *Normandy*. In Normandy it takes the French form—*fleur* as in Har-*fleur*, Hon-*fleur*, &c. How came it there? The Northmen who conquered Normandy introduced it.

*Ford*, as in Ox-*ford*. An important word, and one illustrative of a distinction. *The same word may appear in two allied languages with a difference of MEANING.* With the word before us this is actually the case. At Ox-*ford* there is a river, over which men or beasts can walk; in other words, there is a true *ford* in the English, and Anglo-Saxon, sense of the word. But besides such *fords* as those at Ox-*ford* there is the *Firth* of Clyde, the *Firth* of Tay, &c. in Scotland, and besides these there are such arms of the sea as Carling-*ford* and Strang-*ford* Bays in Ireland. Now, word for word, the Irish *ford*, the Scottish *firth*, and the English *ford*, are the same. Yet the meaning differs. Let the map explain this difference. The *fords*, *firths*, &c. that mean *arms-of-the-sea* re-appear in Norway, Denmark, and Sweden as *fiords*. The *fords* that simply mean *fordable* places in a stream—re-appear in Germany—in Northern Germany as *fords* (Her-*ford*), in Southern as *furths* (Er-*furth*). What does all this suggest? The fact of there having been Danes in England as well as Germans, along with the line they took; also the fact of Northern Germany being a more likely country to have been the father-land of the Anglo-Saxons than Southern. At any rate the forms *ford* and *beck*, as opposed to *furth* and *bach*, indicate this.

*Ham*, as in Grant-*ham*, Notting-*ham*, &c. Like *ford* this illustrates a distinction, and, as such, is an important word. *The same word may appear in two allied languages with a difference of FORM.* It means *home*. This alone shows something. It gives us *one* of the reasons why the fact of so many geographical terms being *Common* rather than *Proper* names is concealed, or disguised. In the modern English there are two forms, one for compounds (-*ham*), one for use as a separate substantive word (*home*). In the Anglo-Saxon there was but one—*ham*. This was pronounced broad and long, something like *hawm*. Now composition has always a tendency to modify the form of words. Hence, the compound changes; the simple word remains much as it was. For it is only in appearance that the *-ham* in Notting-*ham*, &c. is liker to the A. S. *hám* than the simple word *home*. The vowel to be sure is different, but it is to the eye only. The A. S. *á* was (at one period at least) sounded *aw*. Again, the length of the syllable is the main point. In A. S. it was long. So it is in *home*.

But this, though allied to the point which the forms in *ham* illustrate, is not it exactly. It takes, even in composition, *four* forms, *-ham*, *-hem*, *-um*, and *-heim*. Note the distribution of these. The *-heims* belong to Southern Germany, *i. e.* they go with the forms in *-bach*, and *-furth*. The *-hems* go with the forms in *-beck; but only partially*. In the *southern* part only of the area of *becks* do we find them (Arn-*hem*, &c.) In Holland they abound, but not throughout Holland. In the particular province of Friesland they are wholly replaced by the abbreviated and unasperated form *-um*. The details of this are a study by themselves. In Holland they are mixed with *-hem*, and even, occasionally, with *-hem* and *-heim*. We find them as far south as the mouth of the Ruhr in Westphalia—*e. g.* Boch-*um*—but mixed. Then they disappear, till (going eastwards) we get to Brunswick, when they are well-nigh as numerous as in Friesland itself.

To Friesland itself let us now return, and move northward. They fringe the coast of Hanover and Oldenburg, are to be found in Holstein, and abound in Sleswick; but in only one particular part of it, *i.e.*, the parts between Bredsted and Husum. Now here (as in Heligoland and the islands of the coast of Holland) the population is absolutely Frisian—Frisian as opposed to the Germans and Danes around them.

Further still, the peninsula of Jutland, the Danish Isles, Sweden, and Norway, all give us the form in *-um*, and not the form in *-hem*, *-heim*, or *-ham*.

Now I do not say that the exact interpretation of all the facts connected with the distribution of this form in *-um* has been arrived at. At the same time, I submit that to trace it out is both instructive and suggestive. A form of speech called *Frisian* is one of the facts for which we are prepared; another, is the extent to which the *northern* portion of the languages allied to the English adopt it, whilst the *southern* eschew it.

In the islands of the coast of Denmark it both appears and disappears abruptly. In Fohr, we have Duns-*um*, Utters-*um*, Hedehus-*um*, Vits-*um*, Niebel-*um*, Baldiks-*um*, Vreks-*um*, Oevens-*um*, Midl-*um*, Alkers-*um*, Borgs-*um*, Toft-*um*, Klint-*um*, Olds-*um*, Duns-*um*. In Sylt, Horn-*um*, Mors-*um*, Arks-*um*, Keit-*um*, Tuin-*um*—*all in the southern half of the island*. In *northern* Romö, Toft-*um*; in *southern* Romö, none; in Fanö, none; in Amnröm, in Pelvorm, and in Nordststrand, none.

*Holt* = *wood*. This form it preserves in *Northern* Germany; in *Southern*, it becomes *holz* (pronounced *holts*). Compare *-beck*, *-ford*, *-ham*.

*Hurst*—compare Kent, Herts, Beds, and Hunts, &c., with the parts about Hanover and Osnaburg, &c., *i. e.*, Chiselhurst, &c., with Delmen-*horst*, &c.; meaning *copse*, *wood*. Form; simple, as *Hurst*; compound, as *Ash-hurst*. So, also, *Stow*, and *Wit-stow*, &c.

*Ey* = *island*—Trace it accordingly. It is the *-ey* in Orkn-*ey*. It is also the *-ey* in Guerns-*ey*, Jers-*ey*, and Aldern-*ey*. But these islands are French in language, and *-ey* is German, English, or Anglo-Saxon. How came it amongst the *Channel Islands?* How came the Scandinavian form *-fleur?* Refer to *Fleet*, and you have the answer. The Norwegians of Normandy introduced it.

But there are names in [illegible]*y* that lie inland, and belong to places that are *not* surrounded by water. These are eminently instructive, since they show where geology and physical geography meet. The land-and-water conditions have changed since the names were given—Coln-*ey*, Iffl-*ey*, Cherts-*ey*. Traces of the original insular character can generally still be found.

*Mark* = *March*, *boundary*; *e.g.*, the *Marches* of Wales. This suggests hostilities, and a hostile frontier, in countries now united. Follow it into Germany. When there, take some central point—say Hesse. Move in the direction of those countries that, without being German, are contiguous to Germany, *e.g.*, France, Italy, Poland, &c. There will always be a *March*, or traces of it. In the south, Steyer*mark* is one. The old *Marc-omanni* were the *men*-of-the-*march* in the parts about Bohemia. So that the system is an old one. The word *Marq*-uis comes from it.

Study the parts east of Hanover. First comes *Alt-mark*

= *Old March*. Compare the names in the Old March with the names of Western Germany on one side, and those of Poland on the other. They are more Polish than German.

Then comes the *Middle March—Mittelmark*, abounding in names like those of Poland and *Alt-mark*.

Then *Ucker-marck* and *Neu*-mark; this latter meaning the *New March*. What history speaks plainer than these names, or more clearly shows that, at one time, Altmark and the parts beyond were more Polish than German, and that the German frontier gradually enlarged itself eastwards?

But what means *Ucker-* in *Ucker-mark*? Precisely the same in the languages akin to the Polish—the Slavonic—that *Mark* does in the German, or those akin to the English. It is the same as the *Ukr-* in the word *Ukraine*. The system, then, of *Marches* was Slavonic as well as German.

Wherever there have been populations of German origin, there we may look for *Marches*. There is *Marche* in the middle of France, and *Murc*-ia in the middle of Spain; the first from those German *Franks* who gave their name to *France*, the second from those German *Goths* who gave their name to *Cat-alon*-ia (*Goth-land*).

*Ness* = *nose*. Look for this amongst the promontories of the coast. It is commonest in Scotland and Norway (*the Naze*). We expect to find it in Germany and Scandinavia; but we do more. The north-eastern extremity of Asia is Tshuktshi-*Nos*—the language being Russian. In fact, *nos* is a word common to more than one family of languages, viz., that to which the English, &c., that to which the Russian, &c., and that to which the Latin belongs. It is the Latin *nas*-us.

*Stead*, as Hamp-*stead* = *place*. Follow it through *Northern* Germany as *-sted*, through Southern as *-stadt*. Compare *back* and *beck*, &c.

*Ton* (New-*ton*, *Sut-ton* = *South-town*) = *town*; in Anglo-Saxon, *tun*. Common in England, scarce in Germany. Why? See *ford*.

In North Germany and Holland, *tuin* = *garden*; in South Germany, *zaun* = *hedge*. The notion of *enclosure* runs throughout; but in England it takes the sense best adapted to the composition of local names. The following extract from Mr. Kemble illustrates this more fully. Its "usual, although restricted sense, is that of a dwelling, a homestead, the house and inland; all, in short, that is surrounded and bounded by a hedge or fence. It is thus capable of being used to express what we mean by the word *town*, viz., a large collection of dwellings; or, like the Scottish *town*, even a solitary farmhouse. It is very remarkable that the largest proportion of the names of places among the Anglo-Saxons should have been formed with this word, while upon the continent of Europe it is never used for such a purpose. In the first two volumes of the 'Codex Diplomaticus,' Dr. Leo computes the proportion of local names compounded with *tun* at one-eighth of the whole number; a ratio which unavoidably leads us to the conclusion that enclosures were as much favoured by the Anglo-Saxons as they were avoided by their German brethren beyond the sea."

*Toft* = *hamlet*. Commoner, perhaps, in Scandinavia than in Northern Germany, and in *North* Germany more so than in *South*. Important for the reasons that the forms in *-ey* and *-fleet* (*q. vid.*) are important. It appears in Normandy under the abbreviation *tot*—Yve-*tot*, and is Scandinavian or Norse. These Norse names of Normandy are all in the valley of the Seine.

*Thorp*, as in *Mill-thorp-village*. In Northern Germany and Denmark, *-trup;* in Southern Germany, *dorf*. Compare *beck*, *ford*, *stead*, &c.

All these words are not only English, but German as well, and, as the German and Scandinavian tongues are closely allied, we have traced many of them to Norway, Sweden, and Denmark also.

Let us now ask if any words are *exclusively* Scandinavian. If so, they will prepare us for the philological relations of the Scandinavian tongues, and remind us of the Danish invasions. Perhaps, they may do more, viz., point out the Scandinavian localities. *Scandinavian* is a generic name for the Danish, Swedish, Norwegian, and Icelandic. We may say *Scandinavian*, or we may say *Norse;* the two words being of the same meaning.

What are the chief Scandinavian test-words? *Carl-*, *caster*, *firth* (*ford*, *furth*, and *forth*), *kirk-*, *orm-*, *skip-*, and, first in importance, *-by*, as in *Carlt*-on, Tad-*caster*, *Firth* of *Forth*, Pea-*kirk*, *Orms-kirk*, *Skip*-ton. In Anglo-Saxon these would be *Charl-ton*, *-chester*, (or *-cester*), *Chester*-ton, Ebb-*chester*, Ciren-*cester*, Ox-*ford* (over a stream), Dun-*church*, and *Worm* (as in the *Worms-head* in South, opposed to the *Orms*-head in North Wales). Sometimes these forms are mixed, as in *Carlton*. The true Norse form would be *Carl-by*. Generally, there are Saxon forms as well as Danish within the same area. *The converse, however, never takes place.*

However, *-by* (= *town*, *village*) is the chief criterion; New-*by* being Norse, New-*ton* Saxon. Count the *by*-s in Lincolnshire. They are more than one hundred. In Kent there are none. Count the *by*-s in Germany. Not half a dozen. In Denmark they are as common as in Lincolnshire. With these comparisons, work the problem of the Norse distribution.

But we may go further in the way of *minutiæ*. In Scotland the *forths* and *friths* are numerous; the *by*-s few. The same is the case in Norway. This gives us an hypothesis, which the map may either verify or refute.

The Danes of Jutland, and the islands, landed chiefly about the Humber and the Yare; about Grims-*by* and Yarmouth. From the Humber they spread widely in Lincoln, Leicester, Nottingham, Derby, Northampton, north of Warwick (Rug-*by*), and York. In York they follow the Ouse upwards, cross the watershed into Cumberland, Westmoreland, and Annandale. Thence to the Isle of Man, and the *coast* of Lancashire, Cheshire, and Pembroke (Ten-*by* near Mil-*ford*).

The Norwegians take the line of Orkney, the Hebrides, and Man (where they mix with the Danes). Thence to Wales, and Ireland (Carling-*ford*, &c.)

No line is more sharply drawn, than the one of the forms in *-by*. It is also natural. The fens of Lincoln, Cambridge, and Hants, bound it first. Then the Rockingham Forest district in Northamptonshire. What does so in Warwickshire? Within six miles of Rug-*by* (Danish), is Dun-*church* (Saxon). Here we have the legend of Guy, Earl of Warwick; a hero, because he fought against the Pagan *Danes*. Assuredly, his strong arm here did the work of the fens, and forests elsewhere, and acted as a restraining force. So that physical geography, legends, and the internal evidence derived from the analysis of local names are combined. For another instance of the accurate strictness of the Danish frontier, see *Castra*.

The Scandinavians came *after* the Saxons, the Romans *before* them. Trace this by means of the words—

*Castra* = *camp*, in *Chester*-ton, Ebb-*chester*, Ciren-*cester*, and Tad-*caster;* none of which varieties are indiscriminately distributed. For the forms in *-cester*, search the midland counties, from Tow-*cester* to Ciren-*cester*. This, probably, indicates some local difference of dialect.

For *-chester*, see the rest of England, *minus* the Danish area.

In the Danish area, the usual form is *-caster* (Tad-*caster*), a form never found beyond it. On one side of the river Nene, that divides Hunts and Northamptonshire, we have a *Caistor*, on the other a *Chester*-ton. So closely can the line be drawn.

*Coln* = *colonia* = *colony*, as in Lin-*coln* (*Lindi colonia*).

*Foss* = *fossa* = *ditch*. Trace out the different *Foss*-roads.

*Street*, from *Strata*, gives us the line of more than one Roman road, traced by means of the *Stret*-tons and *Strat*-fords.

*Wath* = *ford* = *vadum*.

Now take Wales on one side, and France on the other. The words in *-ville*, and *-mont*, are French, having come in by the Norman Conquest.

The Welsh geographical vocabulary must delay us a little longer. Compare it with the English. The difference is striking. Compare it with the Scotch. There is likeness, but difference also. Compare it with the Irish. There is still likeness; but the difference increases. One pair of the words of importance is *aber* (as in *Aber*-ystwith) and *Inver* (as in *Inver*-ness). The meaning is a *confluence of waters*, sometimes that of two streams, sometimes that of a river and the sea. There are no *Invers* in Wales, and no *Abers* in Ireland. In Scotland there is a mixture of the two forms. The forms in *llan* (*clearance, enclosure*) enormously preponderate. To this add, as some of the chief Welsh elements—

*Avon* = *river*.

*Bach* = *little*, as in *Pen-maen-bach* = *head of little rock*.

*Ceraig* = *rock* = *crag*, as in *Capel Ceraig*.

*Cwm*,—*valley under the escarpment of a hill*.

*Coed* = *wood*—*Bettws-y-coed*.

*Maen* = *stone or rock*.

*Mawr* = *great*—*Pen-maen-mawr* = *head of great rock*.

*Nant*—*valley*.

*Pen* = *head*—*Pen-nant* = *head of valley*.

*Tre* = *place, occupation, home-stead* = *stow*, in Anglo-Saxon and English.

The list may be largely increased; but these are enough for the purposes of illustration.

Trace them in England, France, Scotland, and Ireland.

In England and France they will be found, after a careful search, because the original language of those two countries was allied to the Welsh in its oldest form—*Nantes* in France; in England the numerous *Avons* (rivers), and *-combes* (Stinch-*combe*, &c.) They *decrease* as we go westwards, as may be seen by comparing Monmouth, or Cornwall, with Lincoln, or Norfolk.

The English has spread from Germany towards Wales.

In Scotland, and Ireland, Welsh elements are found, because the present Gaelic of those countries is allied to the Welsh; but they are only found partially. Look for the forms in *mawr* (*môr*), and *pen* (*ben*); as well as for several others, *e. g.*, *aber* and *inver*, already noticed.

In Ireland, note the forms in *Kil* (*Kil*-kenny), and *sliebh* (*mountain*). *Kil* is *cella* = *a saint's cell.* The *Kirks* and *Churches* of England, are *cells* in Ireland. *Bally* = *town.*

*North* and *Western* Scotland agree with Ireland, with a difference. *Ben* (as is *Ben* Lomond) replaces *sliebh.*

All this helps to tell us what languages have come into Great Britain. But there is another question—what languages have gone forth from it? The maps of North America and Australia answer this.

There is a third. Antiquity is illustrated by searches of this kind. A map of *ancient* Gaul and a map of *ancient* Britain agree, just as do the maps of modern Britain (England) and Germany, and just as the maps of modern England and France (modern Gaul) disagree, or agree but partially. This tells a tale of change. History does the same. However, the object of these exercises is to anticipate so much history—to meet it (so to say) half-way. But, before the changes set-in, the languages (as aforesaid) of Britain and Gaul were allied.

In ancient Gaul, we have numerous compounds in—*durum* (*dur* = *water*), *magus* (*magh* = *field*, *plain*), &c. We have the same in ancient Britain.

Britain has now been considered, and it has been considered fully, because it is the field from which our illustrations are drawn. The other parts of the world will be dealt with summarily. The questions, however, will, in the main, be the same. Different grounds will be beaten, but they will be beaten in the same way.

**FRANCE, SPAIN, PORTUGAL, WALLACHIA, AND MOLDAVIA—PARTS OF SWITZERLAND.**—In all these countries, the Latin plays the same part as the Anglo-Saxon or English does in Great Britain.—It supplies the majority of local names. At the same time (as is the case in England), there is the original language of the country preceding it, and certain superadded elements following it; just as the Welsh words in England precede the Saxon in point of time, and the Scandinavian and French follow.

**ITALY.**—Like the countries just named, Italy is Latin in respect to its local names—at least in its central parts. It differs from them, however, in being the *native* country of the Latin language; which the others were not.

The history that the geography of these countries anticipates, is that of the Roman conquests. The Latin words are much disguised; least in Italy and Spain, most in Wallachia, Moldavia, and the Latin part of Switzerland.

This Latin part of Switzerland should be found out by the pupil. It is that part where the majority of the names are neither French nor German, *i. e.*, the Grisons' country.

*The Latin words are much disguised.* This has already been stated. Proof of it lies in the following examples.

The Latin *casa* = *house*, becomes *Gs*, or *Gsch.* This enters into composition with *bella* = *beautiful*, *longa* = *long*, *nigra* = *black*, and becomes *Gs-pell*, *Gsch-leng*, *Gs-nur*.

*Pratum* = *meadow* becomes *pra;* and *pratum bellum* = *beautiful meadow*, becomes *par-biel.*

*Campus* = *field* (as in the French *Champ* de Mars), becomes *Kamp*, *Gamp*, *Tshamp.*

*Vallis* = *valley*, becomes *Val*, *Vel*, *Vil*, *Fl*, and *Pfl;* as *Voll*-gross = great *valley*, *Pflun* = *valley* (Italian, *vallone*). All these are Grison Swiss. The Wallachian and Moldavian localities end largely in *esti*, as *Budesti.*

The Germans that invaded France, invaded Spain also. The Spanish *March* (*Murc*-ia) has been noticed. But besides the Germans, Spain had a peculiar invading nation of its own, *viz.*, the Arabs. Trace these by the forms in *Al*-, as *Al*-geziras, and *Guad*-, as *Guad*-iana. *Al* = *the*, *Guad* (Wady) = *river-course.*

But *Guad*-iana is only half Arabic. The *ana* is the word

*Anas*, which is the ancient name for the river. In what language is *anas* to be found? In that language which bore the same relation to the Latin of the Roman invaders that the Welsh does to the English. This is an obscure language called the Basque, spoken in a corner of the Pyrenees. In this the oldest Spanish names are significant. The *Ast* of *Ast*-urias belongs to the tongue = *rock*. Trace Basque names in Spain just as we traced Welsh ones in England.

GREECE.—Considering how easily the Greek language forms compounds, the small proportion of the Greek geographical names which are significant in the Greek language is remarkable. Stranger still is the fact that though not significant they are in the *Plural* number—Thebæ, Athenæ. It looks as if the Greek tongue was originally foreign to the Greek soil. It is as a part of a classical education that the analysis of Greek, Italian, Spanish, Portuguese, French, Grison, and Wallachian local names is most important. In Spain, where, though complex, the analysis is easy, we have—

*Basque*—*Ast*-urias = *rock*.
*Roman*—*Mont-serrat* = *Mons serratus*.
*German*—*Murc*-ia = *March*.
*Arab*—*Guad*-iana = *Water-course of the Anas*.

To the Greek the obscure language of the Albanians probably bears the same relation that the Welsh does to the English and the Basque to the Spanish.

Trace the Arabic of Spain from the south to the north, beginning with Granada, the most Arab portion of the Peninsula. Sardinia, Corsica, and Sicily are all more or less Latin, *ancient* Sicily being very Greek. *Ancient* Wallachia and Moldavia (Dacia) abound in forms—in *ava* and *ovo*, which re-appear in *modern* Servia.

HUNGARY.—Move towards Hungary from the west, and the German names indent the frontier. Do so from the south and the Servian forms accompany you. Trace the Wallachian forms eastward and you find them in Transylvania—where you also find the German ones, for Cron*stadt*, &c., are German settlements. Nevertheless, Central Hungary has a class of names peculiarly its own—*var*, as in Temes-*var*, being most characteristic. *Var* means *fortress*.

Poland, Russia, Bohemia, Servia, Croatia, Bulgaria, &c.—Sometimes a series of local names can be traced over large areas by simple inspection, *i. e.*, without analysis and without translation. Take up a map of Poland and verify this. Try to pronounce the names of the parts about Warsaw, Posen, or Cracow, and you will soon find that you are in a region of new sounds and new combinations. Look, in the first instance, to these only, and note their distribution. They spread to the German frontier in Altmark, Thuringia, Saxony, Bohemia, and Moravia, and beyond it. They indent Hungary with its peculiar Magyar forms. They thin off (so to say) in Wallachia, Moldavia, Bessarabia, and the Crimea, though in all these countries they can be traced more or less. They re-appear in Bulgaria, Servia, Bosnia, Croatia, Carniola, and Carinthia. In forms more or less fragmentary they may be traced over the Tyrol and Styria, Upper and Lower Austria, and much of Bavaria. Then they fill Russia; and as Siberia is Russian, mix with the original local names of Siberia, and even North-Western America. They can be traced up to Jutland on the *eastern* sides of Holstein and Sleswick—though indistinctly. For all this vast area the nomenclature has a general character or physiognomy. There is a general likeness—but there is difference also. This was what we saw in Germany and Scandinavia. We must, surely, have before us a vast group of allied languages or dialects—a family of cognate languages. Let us first separate it from the other great groups with which it comes in contact. These are—

1. On the *south* the *Italian*. Find the line of demarcation in the parts about Trieste and Venice.
2. Also the *Turkish*.—Look for this on the Lower Danube and the Crimea.
3. On the *south*, and *west*, and *south-west*, determine its relations to the German—in Bohemia, Saxony, and the Valley of the Elbe generally.
4. On the *north* and *east* define the frontier by a line drawn from Lapland and Finland.

The general name for the great class is *Sarmatian*. It falls into two branches:

*a*. The Slavonic in Poland, Russia, Bulgaria, Servia, Bosnia, Croatia, Slavonia, Carinthia, Carniola, parts of Hungary, Moravia, and Bohemia.

*b*. The Lithuanic, in the Governments of Grodno, at Wilna, Kovno, Livonia, Courland, and part of East Prussia.

Here the names recede most from the Polish type. Contrast the local names, which are *not* German, of East Prussia, with the *non*-German ones of Alt-mark or Saxony.

Follow the names from East Prussia (the country of forms in *gallen* and *kullen*) through Courland into Livonia. In North Livonia they will change. Forms in *-ma* (*-land*) will appear, as Testa-*ma*, Tor-*ma*, Vendra-*ma*. In Esthonia these will increase. In Finland we shall have got into a new region of local names altogether; a region of words ending in *-arvi*, and *-yarvi* (*lake*), and in *-jok* (*yok*), *river*, with associated and characteristic forms in *-mois*, *-almi*, *-wesi*, &c.

Much as the Lithuanic agrees with and differs from the Slavonic, will the Lapland forms agree with and differ from the Fin of Finland. Both belong to a large family, which may be traced by its forms in *j-k* (*river*) into Siberia.

Lapland takes us round to the Scandinavian of Norway and Sweden; the contrast along the frontier being manifest.

Still stronger is the contrast between the Fin and the Sarmatian—extreme forms of each being taken from Poland on the one side, and the Duchy of Finland on the other.

One is the region of forms in *-trask*, *-sele*, *-ma*, *-la*, *-yaur* *-yaroi*, *-saloni*, &c., the other of *-bus*, *-pol*, *&c.*.

Of like magnitude and importance with the Fin, Sarmatian, Latin, and German series of local names, is—

The Turk—by which is meant, not merely the Turks of Europe, but the Tartars of Independent Tartary. Trace the names from this as a centre. They are eminently characteristic. There is—

*Dagh*, *Tagh*, *Tau* = *hill.*

*Kara* = *black*, whence *kara-dagh* = *black mountain*: *kara-baugh* = *black garden.*

*Ak* = *white* and *kerman* = *fortress*, hence *Ak-erman* = *white fort*. *Hissar* also = *fortress.*

*Su* = *water*—*kara-su* = *black-water*: *kol* = *lake*, which in Mongolia becomes *nor*.

Persia is characterised by forms in *rud* = *river*, and *-stan* (Hindo-*stan*) = country; Arabia, with Syria and the Holy Land, has its *Bahr* = *sea*, *Beni* = *sons*, *Jebel* = *mountain* (*Gibral*-tar), *Nahr* = *river*, *Ras* = *head* (*promontory*), &c. Trace these over North Africa and Spain.

This is sufficient to indicate the kind of research requisite for the kind of teaching suggested by the present sketch.

Every portion of the world supplies instances, and whether we look to South Africa, South America, or South-eastern Asia (*-agua*, *-ama*, *pulo*), or any intermediate part, the same phenomena present themselves. The more the learner knows of these, the more he will have anticipated a certain amount of historical and philological teaching; and the more he exercises himself in the search for them, the better he will like his map.

Fuller information on the subject of the English local names can be derived from Kemble's *Codex Diplomaticus Ævi Saxonici* (*Preface to vol.* iii.), and Professor Leo's (of Halle) *Treatise on the Local Nomenclature of the Anglo-Saxons* (*Translated by — Williams*:) indeed it is from the former of these works that much of the present notice is taken.

For Russia, consult the *Maps of the Society for the Diffusion of Useful Knowledge*. Here an explanation of the commoner elements is given. *This should be a universal practice.* Thus, *Staro = old*, *Ostrov = island*, *Ozero = lake*, *Mal = little*, *Velsky = great*, *Zemlya = land*, &c.

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